A PROGRAMME TO IMPROVE GROSS MOTOR AND SELECTED VISUAL PERCEPTION SKILLS OF CHILDREN WHO SHOW SIGNS OF DEVELOPMENTAL COORDINATION DISORDER (DCD)

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Declaration

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Abstract

The purpose of this study was to determine the impact of participation in a small group-based perceptual-motor training programme on the gross motor and visual-motor integration skills of children who show signs of Developmental Coordination Disorder (DCD). Two physical education teachers selected 22 children for assessment as potential participants for this study. The Movement ABC (M-ABC) was then administered to this group and the eight children who scored the lowest were invited to volunteer for this study. These children all volunteered and then completed the assessment of their visual-motor integration skills as measured by the Developmental Test of Visual Perception (DTVP-2).

The study followed an evaluative case study design in which changes in the gross motor and visual-motor integration skills of each participant were reported and interpreted individually. The six-week intervention programme was focused on developing the perceptual-motor link between throwing, catching and balancing skills with challenges to visual skills development, especially eye-hand coordination.

A comparison of pre-test, post-test and retention test scores in the M-ABC revealed that the programme had a positive effect on six of the children. The results for the seventh child were inconsistent on each test occasion, leading to the conclusion that he may have a co-morbid disorder related to attention. Improvements in static balance were noted and some children also experienced improvements in their ball skills (aiming and coincident timing) which brings the researcher to the conclusion that the programme was effective for gross motor development. DTVP-2 results showed improvements in eye-hand coordination in five of the seven children. According to the VMI quotient score, only one child improved, one deteriorated and the rest showed no change which brings the researcher to the conclusion that the intervention programme was not effective for visual-motor integration.

Opsomming

Die doel van die studie was om die impak te bepaal van deelname in ‘n klein-groep gebaseerde perseptueel-motoriese oefenprogram op die groot motoriese en visueel-motoriese integrasievaardighede van kinders met tekens van die Ontwikkelingskoördinasie-afwyking (*DCD*). Twee Lewensoriëntering-onderwysers het 22 kinders geïdentifiseer vir assessering as potensiële deelnemers aan die studie. Hierdie groep het die Beweging-ABC toets (*M-ABC*) ondergaan en die agt deelnemers met die laagste uitslae is uitgenooi om aan die studie deel te neem. Hierdie agt kinders het ingestem en daarna is die assessering voltooi deur hulle visueel-motoriese integrasievaardighede te meet deur middel van die Ontwikkelingstoets vir Visuele Persepsie (*DTVP-2*).

Die studie het ‘n evaluerende gevallestudie-ontwerp gevolg waarin die veranderings tussen die groot motoriese en visueel-motoriese integrasievaardighede van elke deelnemer individueel geïnterpreteer en gerapporteer is. Die ses week-intervensieprogram het gefokus op die ontwikkeling van die perseptueel-motoriese skakel tussen gooi-, vang- en balans-vaardighede met uitdagings vir die ontwikkeling van visuele vaardighede, veral oog-hand koördinasie.

‘n Vergelyking tussen die voor-, na- en opvolgtoetse van die *M-ABC* se toetstellings het getoon dat die program ‘n positiewe effek op ses van die kinders se groot motoriese vaardighede gehad het. Die uitslag van die sewende kind was teenstrydig tydens elke toetsgeleentheid en dit het gelei tot die gevolgtrekking dat hy moontlik aan ‘n addisionele afwyking mag ly wat verband hou met ‘n aandagprobleem. Verbeterings in statiese balans is waargeneem en sommige kinders het ook ‘n verbetering in balvaardighede getoon (akkuraatheid en reaksietyd). Volgens die *DTVP-2* resultate was daar verbeterings in oog-hand koördinasie by vyf van die sewe kinders. Volgens die *VMI*-kwosiënttelling het slegs een kind verbeter, een het versleg en die ander vyf het geen verandering getoon nie. Die navorser kom dus tot die gevolgtrekking dat die intervensieprogram nie effektief is vir visueel-motoriese integrasie nie.

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Chapter One

Setting the Context for the Study

Motor development as it occurs during childhood follows a predictable sequence of skill acquisition and emerging patterns of movement coordination. There are children, however, who struggle to learn motor skills that their peers have already mastered. They appear to be physically and intellectually normal but have difficulties performing some age-appropriate motor skills associated with performance in the classroom, at home and on the playground (Van Waelvelde, De Weerdt & De Cock, 2005). The label “clumsy” has often assigned to many of these children although they form a heterogeneous group of individuals who have a variety of different motor control problems and are commonly classified under the broad umbrella term “Developmental Coordination Disorder” (DCD) (Dewey & Wilson, 2001).

Developmental Coordination Disorder

Gibbs, Appleton and Appleton (2007) reported that 6% to 10% of all school-aged children have serious coordination problems compared to their peers in terms of their fine and gross motor skills. Difficulties with coordination usually become apparent when a child does not meet normal developmental milestones and begins to lag behind his/her peers in motor skill performance (Taylor & Fletcher, 1990). For example, some children do not learn gross motor skills such as walking, running, and climbing until a much later age than their peers. Others have problems with fine motor skills such as fastening buttons, closing and opening zippers and tying shoes. Some children move awkwardly and bump into objects and drop things. When children are not able to match their peers in terms of control of either their fine motor skills (*e.g.* dressing themselves or handwriting) or the gross motor skills they need to participate in active recreational and sporting activities, their difficulties usually extend to social isolation and negative self-perceptions (Willoughby & Polatajko, 1995).

DCD is not attributed to a general intellectual, primary sensory, or motor neurological impairment (Gubbay, 1975). According to Missiuna, Gaines and Soucie (1996), the signs that a child may be affected by DCD include low muscle tone, poor balance and coordination skills, incorrect posture and difficulty performing everyday tasks in home, school and play environment. Other signs are abnormal reflexes, associated movements and general clumsiness (Dewey & Wilson, 2001). When children are diagnosed with DCD, it is because they have coordination difficulties with their motor performance, not because they have a neurological defect (Dewey & Wilson, 2001). The motor coordination deficits/delays experienced by children with DCD limit their ability to fully participate in some of the everyday activities of childhood (Polatajko & Cantin, 2006).

Motor Coordination

In Mosby's Medical Dictionary (2009), motor coordination was described as "the harmonious functioning of body parts that involve movement (gross motor movement and fine motor movement) and motor planning" (p. 9). Motor performance is the result of the coordination of multiple muscle synergies that control the actions of multiple joints (Astill & Utley, 2006). Coordination relies on a set of processes that work together to achieve a successful movement performance (Berthier, Rosenstein & Barto, 2005). The motor control problems of children with DCD can be attributed to a breakdown in one or more of these processes and are evident in their difficulties achieving success when performing motor tasks. Missiuna *et al.* (2006) noted the following characteristics in their performance which suggest these information processing difficulties:

- The children have difficulties with motor planning, the timing and amount of force needed during movement, and the integration of information from sensory systems.

- The children often show poor balance and slow reaction and movement times.

Children typically gain control of fundamental motor skills during their pre-school and primary school years. Ulrich (2000) defined fundamental motor skills as "the principal patterns of coordination that underlie later movement skillfulness" (p.251) and according to the Learning Disabilities Association of America (1999) young children learn how to coordinate and control their bodies in the performance of motor skills by moving and using the sensory feedback produced as a consequence of their actions. They divided motor skills into two types:

- Gross motor skills, which are the movements of the large muscles of the body like the arms, legs or the entire body, for movements like crawling, running, and jumping.
- Fine motor skills, which are smaller actions, such as grasping an object between the thumb and a finger or using the lips and tongue to taste objects.

The control of these two types of skills usually develops together since many activities depend on the coordination of both gross and fine motor skills (Learning Disabilities Association of America, 1999).

Vision and DCD

Visual problems are often associated with coordination problems. Numerous studies suggest that children with DCD have deficits in their visual-perceptual skills (Tsai, Wilson & Wu, 2008) although these deficits have not been identified as a contributing cause of coordination problems. In a study by Bonifacci (2004), a significant difference was found in the visual-motor integration abilities of children with high and low gross-motor abilities. Children with lower gross motor abilities had much less accurate visual-motor integration abilities. One or more tests that include challenges to the visual system are always included in the assessment of children who show signs of DCD. For example, Hoare and Larkin (1991) included tests of visual-motor integration and visual perception in their assessment battery designed to categorise children with coordination problems into sub-types of DCD.

Purpose of the Study

The purpose of this study was to examine the impact of participation in a small group-based perceptual-motor training programme on the selected gross motor skills of children who show signs of DCD. Because three of the five sub-types of DCD identified by Hoare (1994) were characterised by difficulties with visual perception, the content of the programme was focused on visual perception coupled with fundamental gross motor skills such as throwing and catching. The impact of participation in the programme on visual-motor integration abilities was also examined.

Research Questions

The following research questions guided this study:

1. What were the effects of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?
2. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual motor integration abilities of children who show signs of DCD?
3. How did the children feel about their participation in the small group-based intervention programme?

Significance of the Study

Henderson and Henderson (2002) presented substantial evidence that early intervention programmes for children with DCD can often make a substantial improvement in their quality of life. This reason by itself is enough to justify any study that examines the potential of a particular intervention programme. One of the most serious implications of DCD in terms of school-aged children is that it includes “a distinct impairment in the development of motor coordination…that significantly interferes with academic achievement or activities of daily living” (Miller, Polatajko, Missiuna, Mandich & Macnab, 2001, p.184). This means that many children with DCD also have difficulty with the execution of fine motor tasks needed for self-care activities, handwriting and drawing (Missiuna *et al.*, 2006).

Although it must be remembered that not all children with DCD have such academic problems, the majority of children with DCD are likely to have significant associated secondary emotional or behavioral problems. DCD can have serious consequences for a child's social, emotional and educational functions (Polatajko, Macnab, Anstett, Malloy-Miller, Murphy & Noh, 1995). "Increased rates of behaviour problems, affective disorders, school adjustment difficulties, and other social problems have also been reported" (Kadesjo & Gillberg, 1999, p. 821). These children often have low self-esteem related to their motor problems and may feel inadequate, incompetent, frustrated and anxious and therefore withdraw from school activities and play (Iversen, Ellertsen, Tytlandsvik & Nodland, 2005; Willoughby & Polatajko, 1995). Some children with motor coordination problems have been found to be introverted and have less self-confidence with respect to both their physical and social skills, including feelings of inferiority and being less well-liked by peers (Miller *et al.,* 2001). It is not surprising that some parents may be overprotective of their children if they are labeled "clumsy", "lazy" or "awkward." This protectiveness may contribute to their social isolation and may weaken their self-esteem.

It is important to remember that for children with DCD, not all skills will be problematic. A child with DCD can be quite competent in performing one motor task but struggle with another (Whitmore, Hart & Willems, 1999). Some children experience difficulties in fine motor coordination, others with gross motor coordination, and still others with a combination of both. Regardless of their movement challenge, children with DCD will not "grow out" of their motor control problems without support and encouragement (Wilmut, Brown & Wann, 2007). Without this support and encouragement, clumsiness is likely to persist through adulthood (Iversen *et al.*, 2005). "Research has in fact convincingly demonstrated that motor deficits from childhood persist into adolescence…and are often associated with academic, emotional and behavioral problems beyond those of peers without DCD" (Hamilton, 2002, p.143).

According to Missiuna *et al.* (2006) it is not only social isolation, poor self-image and victimization that are evident on the long term, but physical health concerns like obesity and mental health problems like anxiety are very common in adolescence. It has recently been shown in studies that children's movement coordination problems are strongly associated with later learning difficulties, including school failure and even psychological problems (Missiuna, 1994). The implications of untreated DCD are so serious that the examination of the potential of one potential programme that may help address the coordination challenges of some children is identified as the significance of this study.

Methodology

A case study approach was followed. According to Thomas and Nelson (2001), case studies are well-suited when insight into the characteristics of either a single individual or particular situation may be helpful in understanding a generic problem. An evaluative case study design was followed that will include an assessment of the impact of the programme on each child, as well as the children's perception of the programme (Barlow & Herson, 1984).

Seven children who showed signs of DCD were invited to participate in the small group-based movement education programme. The programme consisted of gross motor activities (predominantly throwing and catching) that also emphasised challenges to visual perceptual skills like eye-hand, eye-foot and eye-body coordination. These children were identified after administration of the Movement ABC Test (M-ABC) to children referred by their teachers for assessment, based on the teachers' observation of signs of DCD. The assessment of the visual system was limited to four variables from the Developmental Test of Visual Perception 2 (DTVP-2). The results were discussed in relation to any changes found in each child's scores on the M-ABC and the DTVP-2.

After completion of this study, the investigator provided a descriptive report on each participant as an individual. This case-by-case presentation included the following:

1. Changes in selected gross motor skills and visual perception skills will be determined by comparing pre-test, post-test and retention test scores.

2. A comparison between changes in gross motor skills and changes in visual perception skills.

3. The self-report/feedback of each participant about his/her participation in the programme.

4. Observations from the journal kept by the investigator during the sessions to give more insight into each participant's experience.

Limitations to the Study

The following limitations should be kept in mind when considering the results of this study:

- The children who participated in this study "showed signs of DCD," they had not been officially diagnosed as having DCD. The results of the M-ABC indicated that none of the children were below the bottom 15% cut-off point that is usually accepted as the criteria for DCD. They were, however, identified by their teachers as having the signs of DCD and their scores on the M-ABC were low.

- The investigator had to adhere to the timetable provided by the school. This meant that only six weeks were available for the intervention programme. It was possible to complete the pre-testing, post-testing and retention tests outside of this time-frame. This meant that the programme consisted of one session of 45 minutes each week with the investigator.

- Because the investigator only had one session a week with the children, they were provided with additional practice activities that they were asked to do at home. The success of the homework relied on the cooperation of the parents, but there was no way to ensure that the activities were completed.

- The use of small groups instead of individual instruction reduces the specific focus on each specific child's needs. It also introduces social effects which could have had an influence on a particular child's performance.

- The case study method can only track the progress of each child individually. This makes it unwise to make generalisation about other children showing similar signs of DCD, even if they are of the same age.

- A sample size of seven children was accepted as sufficient for this case study approach.

Definitions

The type of programme implemented in this study was labelled a “perceptual-motor training programme.” The following definitions are provided to clarify the focus and content of programmes in this category. It is assumed that, regardless of their focus, all programmes sequence activities to complement the children’s developmental levels and apply teaching/coaching strategies that are ethical and sensitive to children’s self esteem. The following definitions were used in this study to identify the type of intervention programme as a perceptual-motor training programme.

Perceptual-Motor Training Programme

Haywood and Getchell (2005) stated that a perceptual-motor training programme is specifically designed to improve the link between perception (interpreting what is happening in the environment) and action (the appropriate motor performance). Practice activities focus on both specific perceptual skills and specific motor skills in tasks in which there is a criterion set for success in motor performance. It is assumed that if the child meets the criteria, he/she is interpreting the perceptual information correctly. It is considered to be a product-oriented approach because there are specific motor skills that are targeted for learning. In the programme implemented in this study, all learning activities focused on the link between a fundamental motor skill (usually throwing, catching and balancing) and visual perception variables categorised as visual-motor integration skills. Improvements are targeted both for motor skill performance and for perception.

Sensory Integration Programme

Another popular approach when working with children with movement coordination problems is the sensory integration programme approach (Cheatum & Hammond, 2000). This is a process-oriented approach in which one or more of the sensory systems (*e.g.* vision, proprioception, tactile) are taken for the focus of practice activities. The perception of sensory information is assumed, and any kind of responses may be linked to sensation. For example, a programme may include gross motor responses, fine motor responses, and/or verbal responses. The key is to broaden the child’s sensory experiences and help him/her learn to distinguish among the different sensory inputs and what they mean. Movement is used as a means in a sensory integration programme, not as an end.

Gross Motor Skill Development Programme

In a gross motor skill development programme the aim is improvements in the performance of selected motor skills (Nicholls, 1986). The programme usually attends to moor development milestones, providing children with practice activities that follow predictable sequences. It is a product-oriented approach and is commonly associated with the acquisition of the skills needed to play games and sport, dance, gymnastics, etc.

Physical Education Programmes

Physical education and/or movement education programmes include objectives for physical, motor, cognitive, affective and social development that are achieved through participation in gross motor activities (Nicholls, 1986). These are holistic development programmes that are recommended for all children within the context of the school programme.

Summary

In 1975, Gubbay (in Van Waelvelde *et al.*, 2005) defined the term "clumsy child syndrome" to describe children of normal intelligence who were without an identifiable medical or neurologic condition but had difficulties in coordination that interfered with academic performance and/or socialization. It is regarded as a serious problem for children because coordination problems can potentially have a lifelong impact on not only motor performance, but physical, emotional, academic and social well-being. The purpose of this study was to examine the impact of participation in a perceptual-motor training programme that was focused on visual perception coupled with fundamental motor skills such as throwing and catching. The following chapter presents a review of literature related to DCD and visual perception as it relates to children who show signs of DCD.

Chapter Two

Review of Literature

DCD has gained increasing recognition as a serious condition that becomes apparent in childhood but can affect an individual throughout his/her life. Experts have estimated that 6% to 10% of all school-aged children have motor control problems that severely affect their performance of some fine and gross motor skills (Gibbs *et al.*, 2007). These children often have more difficulty than their peers with skills ranging from handwriting to sport skills to self-care activities. According to Missiuna *et al.* (2006), if the total number of children with DCD were distributed evenly across all the primary schools in the United States, there would be at least one child with DCD in every classroom.

The following chapter reviews past academic and professional literature. It explores the topic of DCD in three sections in an effort to better understand what it is and what can be done to reduce its impact on children's lives. In the first section, the characteristics and possible causes of DCD will be presented, as well as the possibility that there may be different sub-types of DCD and that co-morbid conditions cloud efforts to understand DCD. In the second section, special attention is given to the role of vision and visual perception in DCD. In the third section, implications are identified for the development of intervention programmes.

Developmental Coordination Disorder

Individual children with DCD vary greatly in terms of how they are affected, depending on variables such as the source of the disorder, its severity, the particular motor skills affected, and environmental influences. According to the American Psychiatric Association (APA, 1994) a "child who experiences movement difficulties that are out of proportion with their general development in the absence of any known medical condition or identifiable neurological disease, is classified as having DCD". DCD is described in the American Psychiatric Association's Diagnostic and Statistical Manual (DSM-IV, 1994) as a condition in which all four of the following are met:

A. “Performance in daily activities that require motor coordination is substantially below that expected, given the person’s chronological age and measured intelligence.

   This may be manifested by marked delays in achieving motor milestones (*e.g.* walking, crawling and sitting), dropping things, “clumsiness”, poor performance in sports, or poor handwriting.

B. The disturbance in criterion 1 significantly interferes with academic achievement or activities of daily living.

C. The disturbance is not because of a general medical condition (*e.g.* Cerebral palsy or muscular dystrophy) and does not meet criteria for a pervasive developmental disorder.

D. If mental retardation is present, they motor difficulties are in excess of those usually associated with it” (p. 53).

Some uncertainty exists about the diagnosis of DCD because of the lack of specific quantitative assessment instruments (Wilson, 2005). It has been observed that DCD is one possible explanation when a child does not meet normal developmental milestones and begins to lag behind his/her peers in motor skill performance (Taylor & Fletcher, 1990). It has also been noticed that children with a diagnosis of DCD usually have difficulties with perceptual-motor coordination activities, and these activities significantly interfere with activities of daily living, as well as academic achievement (Johnson & Wade, 2007). For example, some children with DCD do not learn gross motor skills such as walking, running, jumping, hopping, climbing and catching a ball until a much later point in time than their peers. Others have problems with fine muscle skills such as the ability to fasten buttons, close or open zippers, or tie shoes. DCD might not be noticed until children try to learn how to write in school or when a teacher notices that they often walk into objects or drop things.

Przysucha, Taylor & Weber (2007) reported that there is still uncertainty about what causes DCD, which makes it very difficult to arrive at either a scientificallyprecise method for the diagnosis of DCD or guidelines for treatment. They identified three lines of investigation that have dominated past literature about DCD.

1. The Developmental Delay Hypothesis suggests that children with DCD are at performance levels of children younger than they are.

2. The Feedback Hypothesis, which suggests that the coordination efforts of children with DCD is negatively affected by their difficulties in using feedback to adapt and modify their performance.

3. The Perceptual-motor Limiter Hypothesis, which suggests that there is a deficit in their information processing system (other than in feedback) that has a negative effect on their motor performance.

All three of these hypotheses are based on the information processing model. Each hypothesis points to a possible breakdown in a different part of the system as a cause for DCD (see Figure 1): The input of information, the central processing of information (CNS) during perception, decision-making and planning, the assembling of coordinative structures during action performance (output), and feedback loops.

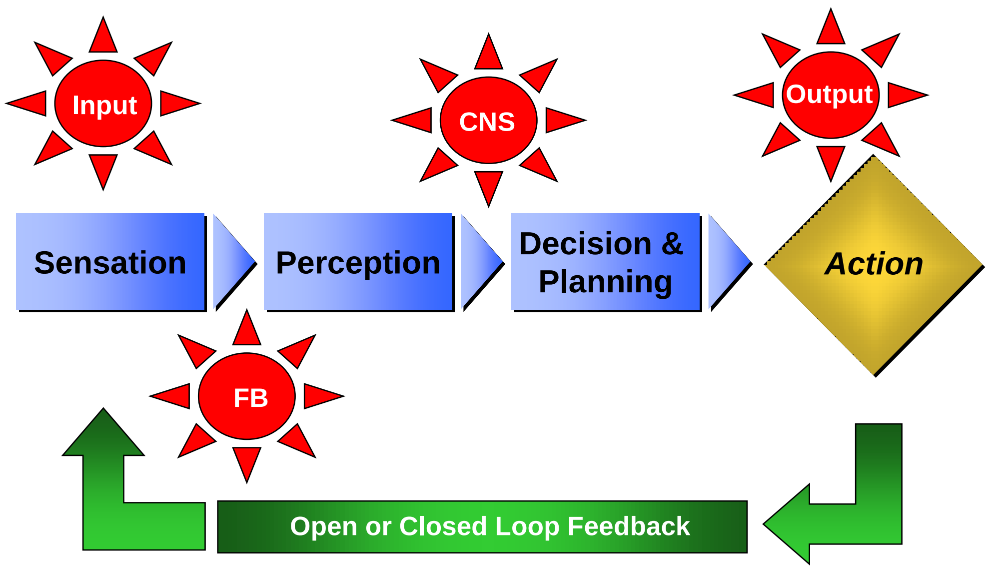

Figure 1. Four possible points of breakdown in information processing associated with DCD.

The Developmental Delay Hypothesis

The Developmental Delay Hypothesis is associated with problems with assembling the appropriate coordinative structures to perform movements/skills. This is a focus on the output of information processing. In order to understand the Developmental Delay Hypothesis the concept of developmental milestones must be understood. There are certain motor skills that are acquired during predictable time periods in a child's life (Learning Disabilities Association of America, 1999). An optimal pattern of motor development has been mapped as a sequence of motor performance milestones. Milestones are fine and gross motor behaviors that emerge over time and are associated with specific age ranges. For example, Table 1 identifies some of the motor milestones for children in age ranges five to seven years old, as well as some warning behavioral signs that indicate possible developmental delays.

Table 1

Examples of motor development milestones for children age's five to seven

What to Expect (ages 5 -7 years)	When to be Concerned
Fine Motor • The child uses a pencil to make shapes (like a square) and then to make letters, words and sentences. • The child draws people, houses and trees with more detail than before (for example: at least 6 body parts when he draws a person). • By age 7, the child will be able to tie his shoes (if given the opportunity to learn). **Gross Motor** • The child will be able to put together a series of motions in order to perform a relatively complicated action such as pumping on a swing, skipping, jumping rope, or swimming. • The child can catch a bounced or thrown ball. • The child should be able to balance on one foot for 10 seconds.	If a child exhibits the following characteristics when performing everyday movement activities such as those listed here, he/she should be examined for possible coordination problems. • The child's limbs seem stiff • The child's muscles seem floppy and loose. • The child is walking on his/her toes. • The child favors one hand or side of his/her body. • The child seems very clumsy. • The child is constantly moving. • The child has trouble grasping and manipulating objects. • The child's motor skills seem to be regressing (becoming less skilful).

Although it is acknowledged that children develop at different rates, there is concern about the normality of the development of children who do not achieve these milestones in either the order predicted by the milestones or within the ages ranges proposed for the milestones (Learning Disabilities Association of America, 1999). DCD is characterised by motor development delays and/or motor skill deficits that have a negative impact on the gross motor abilities and other daily activities of children (Polatajko & Cantin, 2006). It is defined as a motor-based performance problem because the motor coordination deficits/delays experienced limit the child's ability to fully participate in some of the everyday activities of childhood (Polatajko & Cantin, 2006; Dewey & Wilson, 2001). The observable symptoms of DCD include awkwardness and associated movements, poor coordination and general clumsiness (Gibbs *et al.*, 2007), abnormal movements, abnormal reflexes, and delayed achievement of motor milestones (Barnhart, Davenport, Epps & Nordquist, 2003).

Delays in the acquisition of early milestones, such as sitting, crawling, and walking may be early indicators of DCD. However, to associate this delay with a "cause of DCD" implies that the treatment of DCD would be in providing a child with sufficient practice in selected activities that would be appropriate for younger children, and this approach has not been found to be successful. Van Waelvelde, De Weerdt, De Cock and Smits-Engelsman (2004) were able to provide a remedial movement programme that enabled children with DCD to perform successfully a similar quantity of repetitions of selected motor tasks as their peers, but they also reported that there were qualitative differences in the kinematics of their performances. They also found that the changes in the number of successful task repetitions were not maintained for the children with DCD, leading them to conclude that:

- DCD cannot be addressed by only providing developmentally appropriate experiences.
- Children will not eventually "grow out" of DCD.

It is important at this point to remember that DCD refers to children who have marked impairment in the development of motor coordination that is <u>not</u> explainable by any known physical disorder or signs of mental impairment (Polatajko *et al.,* 1995). Delays in reaching developmental milestones are often attributed to underlying physical problems in the neurological system. Failure to achieve developmental milestones is accepted as an indicator of a wide variety of possible problems, not DCD specifically. This may be one reason why many researchers of DCD do not study motor development milestones (the output), but rather look at the other three possible sites for breakdown in information processing (Hamilton, 2002).

The Feedback Hypothesis

Pryzysucha *et al.* (2007) identified the use of open loop and closed loop feedback as a rate limiter on the motor control of children with DCD. Children who are clumsy have difficulty making adjustments in their motor performance, despite the lack of any anatomical reason for their difficulty in correcting their movements. They explained that children with DCD tend to use open loop control (*i.e.* they cannot make adjustments during performance) which is typical of beginners. But children without DCD soon switch to closed loop control as they develop control. They can make adjustments during motor performance which allows them to be both quick and accurate in their movements. However, children with DCD are much less effective in switching. They suggested that this would explain the high incidence of ballistic movements among children with DCD and their over-reliance on pre-programming. This reliance is seen in their difficulty adjusting the speed of their movements, which in turn has a negative effect on precision/spatial accuracy of movements.

Processing feedback is essential when making spatial and timing judgments. When catching a ball, Astill and Utley (2006) found that children with coordination problems initiate reaching movements later than children without coordination problems and were more variable in the time it took them to initiate movements. Children with coordination problems also were found to make significantly larger spatial errors when intercepting the ball. Johnston, Burns, Brauer and Richardson (2002) identified timing as central to all coordinated movement, including continuous movements such as writing or running and discrete movements such as catching or batting a ball. It was their finding that skilled movement requires exact timing, and children with DCD tend to execute movements poorly because they have difficulty adjusting their movements to the timing requirements of tasks.

Deficits in timing were also identified by Geuze and Kalverboer (1994) as a possible source of the motor control problems of children with DCD. They noted that children with DCD often have trouble maintaining a rhythm. Missiuna (1994) reported that children with DCD were slower in their reaction time as well as with their movement time compared to their peers. She speculated that their slower movement time might be because they need more time to use feedback than their peers. When the accuracy demands of a task increase, they also showed significantly slower movement times than their normally developed peers. They commonly display more muscle tension than is normal, which could also account for difficulty in using proprioceptive feedback (*i.e.* the muscle tension overloads the proprioceptive system).

Missiuna (1994) was convinced that many children with DCD rely on external feedback to control their performance, with particular dependence on their vision. Not all studies agreed with this finding. Przysucha *et al.* (2007) investigated the control of stance and the role of visual information in children with DCD. They found that although some children with DCD did rely heavily on visual input in order to maintain balance; this could not be said of children with DCD in general. Rösblad and Von Hofsten (1994) found that children with DCD took longer than children in a control group to complete a movement when visual feedback was provided. These results suggested to them that the children with DCD may use visual feedback about what is happening in the environment in order to perform more accurately.

In their examination of how children with DCD catch a ball, Van Waelvelde *et al.* (2004) analysed the movements of the hand and arm, and identified two specific differences compared to typically developing children. They attributed the difficulties that children with DCD often have when catching a ball to:

- Grasping errors – They close their hand after ball arrives, which could be a problem in timing their actions or because they pre-programme when they will close their hand and cannot adapt to the speed of the ball.

- Hand placement errors – They do not seem to get their hands in the correct place when they try to contact the ball, which could reflect a problem with spatial awareness and the adjustment of hand and arm position according to the flight of the ball.

Van Waelvelde *et al.* (2004) reported that typically developing children will try a new strategy if they don't succeed at catching a ball, while children with DCD tend to try the same strategy over and over again, even if it doesn't work. They concluded that most children can use feedback to adjust their performance both during catching action and on subsequent trials, and children with DCD have difficulties using feedback both during performance and on subsequent trials.

Children with DCD tend to choose less complex activities and closed skills whenever possible, which could be an indication that they do not enjoy or experience as much success with more complicated and open skills (Cairney, Hay, Faught, Corna & Flouris, 2006). This conclusion would be compatible with children who have difficulty processing feedback and adjusting their performances to changing circumstances. Johnson and Wade (2007) observed that children with DCD may be less attuned to their abilities than their normally developed peers. Their research found that children with poor coordination are often more cautious in their judgments about their capabilities which in turn limits their action of choices. Johnson and Wade (2007) also found that the judgment of action capabilities was less accurate in children with DCD than in typically developing children.

Despite the evidence that the use of feedback may be one cause of DCD in some children, two other sites of breakdown in the information processing model have received attention by researchers. Some of these problems are associated with the input of information (the sensory processes). Hamilton (2002) referred to these areas as the apparent difficulties in the children's ability to understand various sensory relationships, including deficits in proprioception, sensory integration, and visual processing. Other problems are associated with the decision-making and planning processes. Together, they are grouped as problems with the perceptual-motor aspects of information processing (Przysucha *et al.*, 2007).

The Perceptual-motor Limiter Hypothesis

Children with DCD have been found to have deficits in proprioception, visual processing and sensory integration (Hamilton, 2002). Iversen *et al.* (2005) also reported that they displayed a general slowness of movement and information processing difficulties. These observations are consistent with breakdowns in the input stage of the information processing system, as well as problems dealing with the information once it has entered the central nervous system for processing (decision-making and planning movements).

Pryzysucha *et al.* (2007) specifically identified problems using sensory information for perception as one of the dominant characteristics of the majority of children with DCD. They were particularly interested in difficulties with proprioception, which could be a sensory problem, a feedback problem, or both. Dwyer & McKenzie (1994) noted that the visual and kinaesthetic deficits of many children with DCD reflect more than a problem with processing sensory information. They also reflect a problem integrating information from different senses in order to form a perception. Their conclusion was supported by Missiuna (1994) who suggested that in addition to feedback, the motor control problems of children with DCD could be associated with movement response selection and/or response programming.

Deconinck, De Clercq, Savelsbergh, Van Coster, Oostra, Dewitte and Lenoir (2006) examined how sensory information was processed prior to and during the motor response of children with DCD in a catching task. They found that visual perception and/or kinaesthetic perception (proprioception) was deficient in many of the children. They also reported problems integrating information from two or more sensory systems (*e.g.* vision and proprioception). The children with DCD had trouble predicting the flight path of the ball, which could be an indicator of problems with anticipation, visual skills or visual memory. These observations are compatible with the findings of Dwyer and McKenzie (1994), who reported that children with DCD have trouble imitating a sequence of movements, that they have observed (a visual memory problem).

Because the intervention programme implemented in this study consisted of physical activities that emphasised gathering and processing visual information, a separate section in this review of literature was dedicated to the examination of vision and DCD. Providing this kind of programme it places this study within the theoretical perspective that the causes of DCD may be found in looking for perceptual-motor limiters in information processing. However, because DCD is a diverse condition, a section will be presented next in which a number of researchers propose that it should be regarded as a collection of different sub-types. If these researchers are correct, then different kinds of intervention programmes may have to be provided for different types of DCD.

DCD Sub-types

Because DCD forms a heterogeneous group it is very difficult to identify whether DCD is one single syndrome or whether subtypes do exist. Although there has not been much agreement among researchers on the proposed subtypes of DCD (Macnab, Miller & Polatajko, 2001), there has been a common motivation behind the discovery of sub-types. Hoare and Larkin (1991) summarised the motivation clearly, stating that if generalisations about the movement problems faced by these children could be made, that specific intervention programmes could be designed specifically to assist them.

According to Missiuna (1996), the “clumsy-child syndrome” is the most common DCD subtype and is evident in children’s’ low muscle tone, poor balance and coordination skills, incorrect posture and the difficulty of performing everyday tasks in home, school and play environment. She reported that other DCD subtypes have been labelled developmental dyspraxia, visual-perceptual dysfunction and sensory integrative dysfunction. Dyspraxia is related to the organisation of movement and/or motor planning. Visual-perception refers to the ability to organise and process visual information in order to make judgements (*e.g.* distance, movement, direction). Sensory integration refers to putting together information from the different senses in order to get a full sensory picture of what is happening.

The Encyclopedia of Mental Disorders (2009) identified the following six symptoms as useful guidelines for categorising children into sub-types. Categorisation is not easy, however, because most children with DCD show signs associated with more than one symptom.

1. General unsteadiness and slight shaking.
2. An at-rest muscle tone that is below normal.
3. Muscle tone that is consistently above normal.
4. Inability to move smoothly because of problems putting together the subunits of the whole movement.
5. Inability to produce written symbols.
6. Visual perception problems related to development of the eye muscle coordination.

Hoare (1994) identified five sub-types of DCD based on the results of the performance of children with DCD on six different perceptual-motor tests. These tests included kinaesthetic acuity, motor-free visual perception, visual-motor integration, fine motor coordination (manual dexterity), gross motor coordination (static balance) and gross motor coordination (running). She proposed the following five sub-types based on her comparison of the children's scores to the mean scores for all the children with DCD. These sub-types were:

Subtype 1:

Children in this group present poor kinaesthetic acuity and running, with average vision scores.

- Below DCD average on gross motor (running) and kinaesthetic acuity.
- DCD average on visual perception and visual motor integration.
- Above DCD average on fine motor and gross motor (static balance).

Subtype 2:

Typical of this group is children with poor kinaesthetic acuity and static balance, but with above average vision skills.

- DCD average on gross motor (static balance and running), kinaesthetic acuity and fine motor.

- Above DCD average on visual perception and visual motor integration.

Subtype 3:

These children are below average on all tasks except locomotion.

- Below DCD average on visual motor, visual perception, fine motor, kinaesthetic acuity and gross motor (static balance).

- DCD average on gross motor (running).

NB: These children appear to have comprehensive perceptual problems. They were also identified by their teachers as having learning problems.

Subtype 4:

Children in this group present good kinaesthetic acuity with below average visual perception.

- Below DCD average on visual perception.

- DCD average on gross motor (static balance) and visual motor integration.

- Above DCD average on kinaesthetic acuity, fine motor and gross motor (running).

NB: Rather than a general perceptual problem, these children appear to particularly have visual perception problems.

Subtype 5:

These children show poor motor tasks compared to perceptual tasks.

- Below DCD average on gross motor (running and static balance), fine motor and visual motor integration.

- DCD average on visual perception.
- Above DCD average on kinaesthetic acuity.

NB: These children appear to have the most difficulty executing motor tasks.

Hoare (1994) concluded her research by stating that she believed that DCD is a collection of different motor control problems. Ideally, an intervention programme would address the specific profile of the specific child involved. It is important to remember that the sub-types identified above were the product of the analysis of children with DCD. In other words, when a child scored “above average” on a test, it was not above average for a typically developing child, but rather than for a child who has been diagnosed with DCD.

Barnhart *et al.* (2003) also identified five different subtype profiles of DCD:

1. Better gross than fine motor skills but both below normal, while static balance and visual-perception skills are normal for DCD.
2. Good upper-limb speed, dexterity, visuomotor integration and visual-perception skills, but poor kinaesthetic ability and balance.
3. Good motor performance on many skills, but poor kinaesthetic and visual abilities.
4. Good kinaesthetic ability but poor visual and dexterity skills.
5. Poor running speed and agility, but good visual-perception skills.

One conclusion made by Barnhart *et al.* (2003) was that the different sub-types identified for DCD are influenced by the design of motor tests being used. In other words, researchers must be careful to select test items that accurately measure distinct variables and avoid those tests that measure several variables in an integrated fashion. Hoare (1994) also highlighted this difficulty in the assessment of children’s movement.

Co-morbidity

It is common for children who have been diagnosed with DCD, to also be diagnosed with other disorders. Henderson and Henderson (2002) reviewed research on DCD and found that co-morbidity was so prevalent that less than 50% of the children diagnosed with DCD have only DCD. Figure 2 is their diagramme illustrating the rate of co-morbidity of DCD with dyslexia and Attention Deficit Hyperactivity Disorder (ADHD). Only 26 out of 200 children had DCD by itself, 19 had dyslexia and 8 had ADHD. A total of 22 children had DCD with dyslexia, 10 had DCD with ADHD and 7 had ADHD and dyslexia. The remaining 23 children had all three disorders.

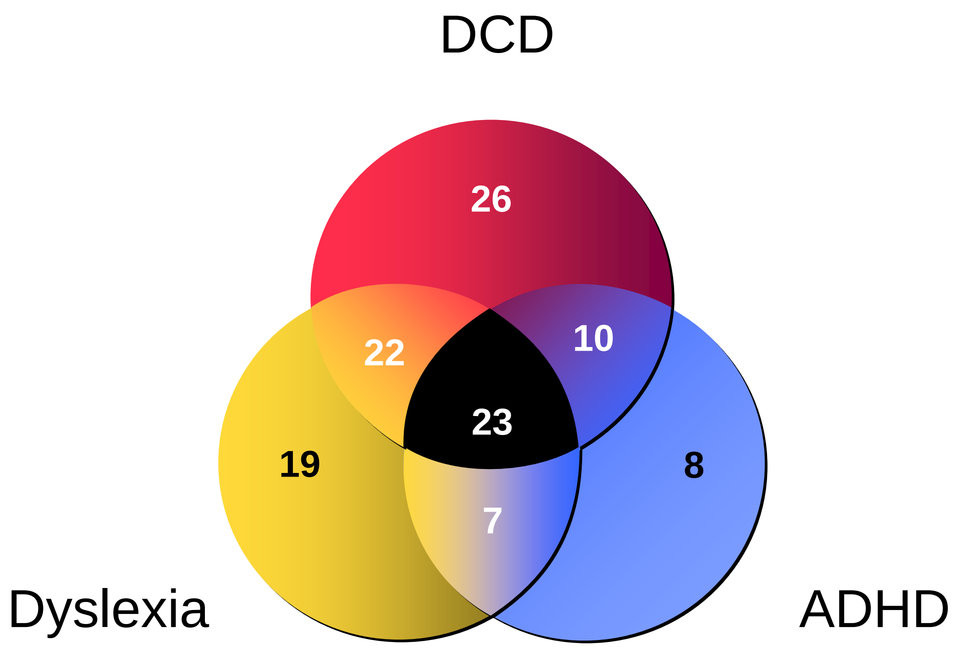

Figure 2. The rates of co-morbidity among a sample of children with DCD, Dyslexia and/or ADHD (Henderson & Henderson, 2002, p. 22).

Mild motor impairments have been related to behavioural disturbances such as hyperactivity, impulsiveness, learning disabilities, aggressive antisocial conduct, anxiety and depression, and unfortunately with increasing movement clumsiness, the severity of co-morbid problems also increases (Largo, Fischer & Rousson, 2003).

Van Waelvelde, De Weerdt and De Cock (2005) stated that about 50% of children with ADHD also appeared to have DCD. An illustration of the ADHD/DCD correlation was described by Wilmut *et al.* (2007). They suggested that deficits in the allocation of attention could explain some of the coordination problems exhibited by children with DCD. They were convinced that many children with DCD have an inability to allocate their attention optimally in movement situations.

Jongmans, Smits-Engelsman and Schoemaker (2003) provided similar statistics to document the co-morbid relationship between DCD and learning disabilities (LD). One study found that among children with DCD, the presence of LD increases the likelihood of low performance of perceptual-motor tasks that are part of many daily motor activities. Children with a combination of DCD and LD scored very low on tasks that measured dynamic balance and unimanual dexterity, compared to children with only DCD. Despite the high incidence of co-morbidity, these findings support the separate diagnosis of DCD and LD because children with one of these developmental disorders do not always have the other (Jongmans *et al.,* 2003).

One of the challenges of the co-morbidity issue is the problem of knowing how to design and implement treatment programmes for children with multiple disorders (Henderson & Henderson, 2002). Another challenge is finding assessment instruments that can measure accurately the degree of severity in the co-morbid conditions. Research is currently being done is these problem areas to find ways to address the impairments of children with DCD and with DCD and a variety of co-morbid conditions. This is particularly challenging because Henderson and Henderson (2002) estimated that as many as two-thirds of the children diagnosed with DCD also have co-morbid disorders. They remarked that co-morbidity was so common it made them wonder if DCD is a separate movement disorder or a symptom of a variety of other disorders.

DCD and Visual Perception

Hoare and Larkin (1991) associated the difficulties that children with coordination problems have controlling the speed, force and direction of their movements with task demands on visual perception. Hoare (1994) found that two of the five sub-types she identified within DCD displayed extremely low scores on tests of visual perception, and visual perception was no better than the DCD average for children in the remaining three sub-types.

Visual perception depends on many different visual abilities. Haywood and Getchell (2005) identified those visual abilities that are typically associated with the development of children's visual systems. Those abilities included:

- *Perception of size constancy:* The ability to judge accurately the sizes of different objects that are at varying distances (normally mature by age 11).
- *Perception of figure-and-ground:* The ability to find and focus on an object/figure in a distracting background.
- *Perception of whole-and-parts:* The ability to discriminate the parts of an object from its whole (normally mature by age 9).
- *Perception of depth:* The ability to judge the distance of an object from one/s own body as well as to see it is three-dimensional.
- *Spatial orientation of objects:* The ability to distinguish between vertical and horizontal positions of an object and to recognise an object even if it is upside-down, rotated, etc.
- *Perception of movement:* The ability to find and then track a moving object (normally mature by age 10). A child's ability to move his/her body in relation to a moving object normally matures by approximately age 12.

Hamill, Pearson and Voress (1993) were interested in determining the types of variables of visual perception that were critical for identification of deficits. They listed only four types, suggesting that valid and reliable instruments to test the specific visual abilities and skills within each type will be the key to accurate diagnosis of deficits in visual perception. Those four types were:

1. "Form Constancy: the recognition of the dominant features of an object or figure when they appear in different sizes, shadings, textures and positions.

2. Figure-ground: the recognition of figures embedded within a general sensory background.

3. Position in space: the discrimination of reversals and rotations of figures.

4. Spatial relations: the analysis of forms and patterns in relation to one's body and space" (p. 2).

Numerous studies suggest that children with DCD have deficits in their visual-perceptual skills (Tsai *et al.*, 2007). Hoare (1994) identified one subtype of children with DCD characterised by their visual dysfunction. Rösblad and Von Hofsten (1994) associated impairments of visual perception with the motor coordination problems observed in children with DCD. For example, they stated that children with motor impairments as a group seem to be more dependant on visual information of the target for end-point accuracy than children without such impairments, which has a negative influence on their movement speed and accuracy. Because the visual-perceptual system is regarded as the dominant modality for controlling goal-directed actions, deficits in processing visual information can lead to problems in decision-making and movement planning as well as feedback control as discussed earlier (Tsai *et al.*, 2007).

Mon-Williams, Pascal and Wann (1994) stated that because vision has a primary role in perception, and children with DCD present with eye-hand, eye-foot and/or eye-body coordination problems, that it was important to determine what parts of the visual system might be contributing to those problems. They examined 10 ophthalmic variables of vision in a battery of tests of visual ability of children with DCD. Their results revealed no significant deficits in nine of the 10 tests of the ocular health. The nine visual variables which were within the normal range were:

1. Visual acuity – (static visual acuity).

2. Near-point of Convergence – (diplopia as object moves toward eyes or one eye diverges).

3. Ocular motility – (pursuit tracking).

4. Pupillary reactions – (reflexes to light).

5. Ophthalmoscopy – (to determine if any pathology exists, especially on retina).

6. Refraction – (to determine if there is a need for corrective eyewear).

7. Amplitude of accommodation – (eye's ability to change focus from far to near).

8. Central visual fields – (check light sensitivity within the central 30 degrees of the visual field.

9. Colour vision.

There were some of the children with DCD who displayed difficulties with ocular-motor balance. Ocular-motor balance or binocular coordination is assessed by covering each eye in turn while the other eye maintains fixation on a small target visible to both eyes. Problems with ocular-motor balance can indicate presence of strabismus, which is confirmed to be a characteristic of some sub-types of DCD (Mon-Williams *et al.*, 1994). This research is important because it leads to the conclusion that the motor control problems of children with DCD associated with their visual system cannot be explained by problems with their visual hardware, but rather with their integration and interpretation of visual information (*i.e.* visual perception).

Vision and Feedback

Astill and Utley (2006) suggested that children with DCD rely more on visual information rather than proprioceptive information for feedback to control their movement performance, as opposed to typically developing children who shift from visual to proprioceptive information early in the motor learning process. For example, the manipulation of visual information during walking has been shown to affect balance in children with DCD to a greater extent than typically developing children (Deconink *et al.*, 2006). A greater visual contribution to walking was also found in children with DCD when compared to their typically developing peers, which was attributed to their use of vision for feedback on their balance control (Zoia, Barnett, Wilson & Hill, 2006).

Vision and Eye-hand Coordination

An estimated at 5 – 10%, of the ‘normal’ population of children present deficits in the coordination of eye and body movements (Wilmut *et al.*, 2007). The most studied eye-body coordination is eye-hand coordination which typically relate to the eye looking at an object before the hand starts moving towards it (Berthier *et al.*, 2005). Eye-hand coordination is crucial for success in ball games when what the eyes see is translated into physical responses, such as tracking the flight of a ball in order to put the hands in position to catch it.

Deconinck *et al.* (2006) examined how sensory information is processed prior to and during the motor response. They found that visual perception and/or kineasthetic perception (proprioception) was deficient in many cases of DCD and also noted that children with DCD had problems integrating information from two or more sensory systems (*e.g.* vision and proprioception). They speculated that the trouble children with DCD have predicting the flight path of a ball could be a problem with anticipation or even visual memory *(i.e.* they have difficulty remembering what happens when a ball starts on a certain flight path). They noted that it is clear that children with DCD have problems catching a ball and that their hands stay open or close at wrong time. What is not clear is whether these are problems with finger proprioception or a visual problem in identifying where and when the ball will arrive.

Other Visual Deficits

Johnson and Wade (2007) reported that a variety of perceptual difficulties could be associated with the movement difficulties of poorly coordinated children. In a study by Bonifacci (2004), a significant difference in visual-motor integration between children with high and low gross motor abilities was found in the absence of significant differences in either other perceptual skills or intellectual ability. Wilmut *et al.* (2007) stated that past research on DCD showed that deficits in children with DCD were most pronounced on visual-spatial tasks regardless of whether a motor response was needed. Parush, Yochman, Cohen and Gershon (1998) confirmed this when they found that children with DCD performed poorly in both motor and motor-free tasks. The conclusion they came up with was that children with DCD have problems with both visual perception and visual-motor integration. Current data support the view that visual spatial processing is implicated in DCD (Wilson & McKenzie, 1998).

Dwyer and McKenzie (1994) found that children with DCD had trouble imitating a sequence they had observed and reasoned that their poor performance could be due to inefficient visual rehearsal strategies. If imitation immediately followed the demonstration, the children with DCD were similar to their normal peers. However, when there was a time delay, children with DCD were significantly less accurate in remembering while often reproducing the actions more quickly than normal peers. The researchers concluded that it is possible that children with DCD do not use visual rehearsal strategies as effectively as normal peers.

Intervention Programmes

Designing and implementing programmes for children with DCD has never been a straightforward task because there seem to be different sub-types, each presenting its own unique needs (Hoare, 1994). Floet (2006) identified seven critical ‘building blocks’ of motor functioning. She further noted that any delay or impairment in one of these could cause a developmental problem in the development of coordinated movement, including DCD. Their implication was that each of these building blocks deserves a central place in the planning of movement programmes for all children.

1. Muscular tone.
2. Gross motor skills.
3. Fine motor skills.
4. Muscular strength.
5. Motor planning.
6. Sequencing and speed of movements.
7. Sensory integration.

Miyahara and Wafer (2004) attempted a five-week individualised programme (2 xs per week for 30 min. sessions) with children with DCD, attempting to provide practice activities in those areas in which they appeared to have deficits. They did not achieve any significant improvements, attributing this outcome to:

- The programme was not frequent enough and/or the training sessions were not long enough.
- The presenters of the programme had underdeveloped teaching skills and used less than optimal strategies.
- Individual deficits were not addressed by the intervention programme.
- The pre- and post-tests of DCD were not sensitive enough to discriminate changes in motor proficiency.

Miyahara and Wafer (2004) agreed with previous authors that it is difficult to decide how to structure an intervention programme when the etiology of DCD is not yet understood. They also commented on the problems associated with these tests used to diagnose DCD. They noted that normative tests do not always identify children with coordination difficulties and that clinical judgment based on extended observation of the child must also be considered. The also commented that some intervention programmes may have short-term positive effects, but the improvements appear to be short-term. They stated that DCD must be monitored for an extended period in order to track changes so that practitioners could find strategies for preventing relapses. This puts the process of the assessment of children’s movement at the centre of challenges to presenting effective intervention programmes.

The Challenge of Assessment

Despite lists of characteristics and/or signs of movement problems, it is very difficult to identify what distinguishes the child with DCD from children with normal motor behaviour. According to Van Waelvelde *et al.* (2005) four major problems make the diagnosis of DCD quite challenging:

1. The absence of a “gold standard” for determining of the level of motor performance of discrete variables: Although the Movement ABC test battery (M-ABC) is universally accepted as a diagnostic instrument, there are still concerns about its accuracy in all cases.

2. The determination of the “degree” of impairment that is required before a child will be classified as having DCD: Even when a test is able to discriminate among children in terms of their motor control proficiency, at what point is the criteria set to classify some children as having DCD.

3. The assessment of the impact of the impairment on daily activities: A very helpful tool is the use of a behavioural checklist that can be completed by teachers and/or parent to identify any coordination problems in the completion of activities of daily living.

4. The determination of the “degree” of interference in performing activities of daily living that is required before a child will be labelled as being at-risk for DCD: This is even more difficult than setting criteria for test scores because children live in different environments, and there may be different expectations for motor proficiency for different children.

There are several reasons why early diagnosis and intervention are important to address the movement problems of children who show signs of DCD. A strong argument was made that if functional improvements can be made in motor performance, it may be possible to prevent the development of some of the secondary problems that typically affect children with DCD (Polatajko *et al.*, 2005). For example, they stated that if intervention was started early enough it was far more likely not only to improve children’s coordination and motor skills, but also improve their self-esteem and socialisation skills.

Failure to diagnose and address the motor coordination problems seen in children with DCD may have major consequences in adult life. Gibbs *et al.* (2007) cited extreme cases in which they proposed there is a link between DCD and adult unemployment, psychological disorders, substance misuse and poor interpersonal skills. It was their position that early identification and intervention could reduce the impact of DCD on the development of social, emotional and behavioural problems, and also encourage children to understand and accept their limitation. A study by Mandich, Polatajko, Macnab and Miller (2001) was encouraging in this regard, finding that when children with DCD received treatment, the consequences of DCD began to reverse. This emphasises the importance of presenting intervention programmes that help children who show signs of DCD improve their motor coordination in ways that will impact on both their participation in the school and play activities of childhood, but also the activities of self-care associated with daily living.

Types of Intervention Programmes

What kind of intervention programme works? The ideal approach would enable children to reach their full movement potential while at the same time minimise the impact of their coordination challenges on secondary emotional and social problems (Polatajko *et al.,* 1995). The content and teaching strategies implemented in programmes for children with DCD are varied and the value of some of these interventions has been debated (Mandich *et al.*, 2001). Bearing in mind an individual child's needs and the heterogeneity of DCD, it is important to realise that no single approach works for all children (Niemeijer, Smits-Engelsman, Reynders & Schoemaker*,* 2003). What seems to work for one child, may not work for another. However, without intervention, these children will continue to exhibit poor motor skills and may develop deficits in other areas of life as well (Barnhart *et al.*, 2003).

Miyahara and Wafer (2004) noted that intervention programmes can be generally classified into one of two approaches:

1. The process-oriented approach where physical activities are selected that focus on a particular sensory process or perceptual ability. The premise is that if the underlying abilities improve, they will contribute to the improvement of the performance of any skills that rely on those abilities.

2. The task-oriented approach where physical activities are selected that are considered relevant to the child's lifestyle, and those activities are practiced. The premise is that by acquiring certain specific but common skills, those skills can be transferred and modified to allow the child to perform other skills successfully.

The Process-oriented Approach

According to Sugden and Chambers (2003), the process-oriented approach assumes the child has not developed certain underlying abilities adequately for his/her age. Because these abilities are thought to be necessary for the successful performance of motor skills, the child's performance will be inadequate until the abilities themselves are improved. Laszlo and Bairstow (1985) presented a process-oriented approach treating only the kineasthetic problems associated with DCD in their efforts to improve the children's motor control.

Sensory-motor development programmes are considered to be process-oriented. Cheatum and Hammond (2000) published their programme, which suggested that movement programmes for children be organized into six thematic areas:

1. Body awareness (including body image, body concept, body schema, laterality and directionality).
2. The vestibular system.
3. The proprioceptive system.
4. The tactile system.
5. The visual system.
6. The auditory system.

Cheatum and Hammond (2000) recommended that the choice of content focus areas and specific activities be made on an individual basis following an assessment of the needs of the children involved. There is no research to support claims that the process-oriented approach is highly effective. In a study by Polatajko *et al.* (1995) the process-oriented approach was used, and the results revealed that the children did not improve. The authors concluded that the children's motor coordination problems were very resistant to treatment.

Task-oriented Approach

This approach concentrates on specific movement tasks or motor skills as the content of the programme. The programme assumes that if the skill practice activities have enough variety in them, skill generalisation will be promoted and the child will become more competent moving in his/her environment. The strength of this programme is that it is focused specifically on tasks that are causing the child difficulties (Sugden & Chambers, 2003) and has also be called the skill-specific approach.

The task-oriented approach involves the repetitive training of a specific skill and has been identified as more successful than the process-oriented approach (Mandich *et al.*, 2001). Johnson and Wade (2006) also found that interventions targeting specific functional skills were the most beneficial for children with movement difficulties like DCD. Iversen *et al.* (2005) recommended that activities such as swimming, bicycling and skiing be used as part of an intervention programme, because they are continuous skills that follow a repetitive pattern. Once the pattern is learned through repetition, children with DCD can become successful.

Task specific interventions focus on direct teaching of the task and part-whole learning (*i.e.* breaking the task up into smaller units and then linking the units together for a whole-task performance). Pless and Carlsson (2000) recommended the skill-specific/task-specific approach. There have been some variations on this approach. For example, Niemeijer, Schoemaker and Smits-Engelsman (2006) labelled their approach neuromotor task training (NTT), but NTT is also a task-oriented, skill-based approach that emphasises the teaching of task-specific activities.

Unfortunately research on the effects of intervention programmes is still limited (Iversen *et al.* 2005) and programmes designed specifically to treat children with DCD are not widely published (Pless & Carlsson, 2000). After reviewing the literature on intervention programmes for children with DCD, Peters and Wright (1999) came to the conclusion that considerable research still needs to be done before comprehensive guidelines for effective intervention programmes will be available.

Summary

Coordinated movement can be thought of as the mapping of perceptual (input) to motor (output) actions. From an information processing perspective, four possible sites of breakdown have been proposed: Sensation and perception, decision-making and planning, movement execution, and feedback. A breakdown in processing in any one or more of these areas can result in poor motor coordination (Wilson & McKenzie, 1998).

"There is a great need for treating this disorder because most children do not outgrow DCD" (Niemeijer *et al.,* 2003, p.568). Because the cause of their clumsiness is still unknown, there are still only theories that attempt to explain its etiology. Although the over-all objective of all intervention programmes is to improve the children's motor skills and ability to function in everyday life, different approaches have been attempted. The determination of the best type of intervention programme for children with DCD is particularly difficult because there is so much variety in how the disorder affects the children, and many of the children have co-morbid disorders as well. However, Miyahara and Wafer (2004) noted that children with DCD share two common needs:

1. They need to acquire culturally-relevant skills that will allow them to function in academic achievement settings (*e.g.* fine motor skills) as well as physically active play situations (*e.g.* gross motor skills).

2. They need to develop and maintain positive self-esteem, which has been found to be undermined by their continuous experiences of "clumsiness" in front of their peers and in performance situations.

It is the purpose of this study to deliver a task-oriented programme to a small group of children who show signs of DCD in an effort to improve both their motor proficiency and their visual perception. The methodology is described in the following chapter.

Chapter 3

Methodology

In this chapter, a brief description of the research method that was followed in this study is provided. The assessment instruments used to measure motor proficiency and visual perception are presented, as well as the procedures followed in the implementation of the study. The final section of this chapter describes the manner in which the data were reported and interpreted.

Research Design

The researcher will make use of an evaluative case study approach and gather both qualitative and quantitative data (Thomas & Nelson, 2001). Quantitative data was the result of the administration of two standardised assessment instruments. Qualitative data were the product of reports about participation in the programme made by the children as well as comments about the children's experiences recorded in a journal kept by the investigator throughout the six weeks of the intervention programme.

"Case study research involves the intensive study of a specific case" (Gratton & Jones, 2004, p.97). A case refers to a specific instance and includes anything from an entire organisation to a single individual. A case study is a type of descriptive research in which the investigator tries to get an in-depth understanding of each case (individual). Gratton and Jones (2004) identified four characteristics of case study research:

1. A phenomenon is studied as it occurs in specific cases.
2. Each case is studied in depth.
3. The phenomenon is studied within its natural context.
4. The perspectives of the individuals who are involved in the case are explored.

Gratton and Jones (2004) also identified a number of questions to answer surrounding the issue of sampling that are specific to case study research. For example, they stated that the choice of case or cases should not be random but rather have a purpose related to gaining insight into the phenomenon of interest. They recommended that the investigator should consider:

- How many cases should be included in the research? Is it appropriate to present details about a single case, or would details about several cases be more revealing about the phenomenon?
- How accessible is the sample for participation in the case study?
- Is it desirable to identify a case that will demonstrate a particular model/theory well?
- Is it possible to identify a “typical” case so that the results could be generalised to other cases?

Because an evaluative case study involves the description and interpretation of a single case, the data to evaluate the merit of a single type of intervention programme or professional practice is needed (Thomas & Nelson, 2001). For the purpose of this study, the investigator determined that a small selected sample of children who specifically show signs of DCD would provide insight into the effectiveness of an eye-hand coordination intervention programme delivered in a small-group format.

Selection of the Assessment Instruments

A test of gross motor proficiency that was sensitive to the identification of the signs of DCD was essential for this study. The standardised M-ABC was identified as suitable for this study. Because the investigator wanted to trace the influence of the programme specifically on visual-motor integration in children who show signs of DCD, a second standardised test, the DTVP-2, was also selected for administration.

The Movement Assessment Battery for Children (M-ABC)

The M-ABC is the most widely used test to identify DCD and the most often cited test in the literature (Henderson & Henderson, 2002). Deconinck *et al.* (2006) stated that the M-ABC is a widely used test that has been proven to be a valid measurement for detecting motor coordination problems. The administration of the M-ABC in order to identify children, who may have DCD, usually consists of two parts:

- A checklist which is normally completed by the child's parent or any adult who is familiar with the child's motor competence, ranging from active play behaviours to activities of daily living.

- A motor performance test battery of eight developmentally appropriate test items. There are four different test batteries for four different age bands specifically created to make sure that the test items and the norms for interpreting the scores are applied to children from the same age group.

Within each test battery, the eight test items are grouped under four broad headings: Manual dexterity (three test items), ball skills (two test items), static balance (one item) and dynamic balance (two items).

Test Items

For the purpose of this study, the gross motor skill test items for ball skills, static balance and dynamic balance from Age Band Two were selected. The test items in this age band were suitable for children 7 and 8 years old, the age range of all the children in this study. The investigator decided only to administer the tests related to gross motor skills since gross motor proficiency was a dependent variable in this study, *i.e.* ball skills, dynamic balance and static balance. The M-ABC supports the administration of individual test items and provides norms for interpreting the individual test item scores. The test items from Age Band Two that address gross motor proficiency are the following:

1. Ball Skills

- One-hand bounce and catch (coincident timing).

  The child has 10 attempts with each hand to bounce a tennis ball on the floor and catch it with the same hand. There is no time limit.

- Throwing bean bag into box (aiming).

  The child has 10 attempts with the dominant hand only, to throw/toss a beanbag into the target box from a distance of 2m. There is no time limit.

2. Dynamic Balance

- Jumping in squares

  The child stands in the first of six consecutive squares and then tries to jump with both feet simultaneously through the remaining five squares, landing in a balanced and controlled position in the last square. There is no time limit.

- Heel-to-toe walking

  The child attempts to walk on a 2cm wide line taped on the floor. The goal is to take 15 consecutive steps where the heel of the one foot is placed against the toe of the other foot with each step taken. There is no time limit.

3. Static Balance

- Stork balance

  The child tries to stand (balance) on one leg with the sole of the other foot touching the inside of the supporting knee, while both hands rest on the hips. The goal is to maintain this position without losing balance for as long as possible, up to a maximum of 20 seconds. Both legs are tested.

Scores on the M-ABC

According to the M-ABC test manual (1992), the raw score for each test item can be converted to a standard score for the purpose of comparison. A scale for conversion of raw scores to standard scores was created based on normative data within each Age Band (see Appendix A for Age Band 2). The converted scores for each test item range from 0 to 5 (Table 2). Although the M-ABC supports the administration of individual test items and provides norms for interpreting the individual test item's standard score, a total impairment score cannot be reported unless the full test battery from a given age band is executed. When the full test battery is administered, the total of the standard scores can be converted to a percentile score that can be used to determine the severity of a child's coordination challenges. For example:

- Scores below the 5th percentile indicate a distinct motor problem and/DCD.
- Scores between the 5th and 15th percentile indicate a severe risk for motor problems and/or DCD.

Because the purpose of this study was to examine the effects of an intervention programme on the gross motor skills of children who showed signs of DCD and not the impact of the programme on DCD as a whole, the test items dealing with fine motor coordination were not administered. This meant that a total impairment score could not be calculated.

Table 2

M-ABC rating scale for the interpretation of standard scores

Standard Scores	Descriptive Rating
0	No signs of DCD
1	At risk for DCD
2	Mild signs of DCD
3	Worrying signs of DCD
4	Severe signs of DCD
5	Classified as having DCD

Developmental test of Visual Perception 2 (DTVP-2)

Mon-Williams *et al.* (1994) reported that children with DCD present with eye-hand, eye-foot and/or eye-body coordination problems. They highlighted the importance of addressing visual-motor integration challenges when working with children with DCD. It was necessary to find an assessment instrument that could track changes in children’s visual perception abilities related to visual-motor integration. The DTVP-2 provided the necessary content and scoring options to meet the requirements for measurement in this study.

Hammill *et al.* (1993) wrote the DTVP-2 test manual. They worked over a period of 10 years to arrive at a valid and reliable test battery that was designed specifically to evaluate a child’s visual perception through the performance of both motor-reduced and motor-enhanced tasks. The battery consists of eight test items, four of which require minimal movement on the part of the child and four of which require some eye-hand coordination in order to complete each of test items.

The DTVP-2 test is recommended as an assessment instrument to determine the degree of visual perception and/or visual motor integration difficulties as well as to verify the effectiveness of intervention programmes (Hammill *et al.*, 1993). Because the intervention programme in this study was a six-week perceptual-motor training programme emphasising gross motor activities that challenged eye-hand coordination, it was anticipated that only the visual motor integration of the participants might be affected. The investigator also did not want to “over-assess” the participants. The administration of the four motor-enhanced tests of the DTVP-2 took approximately 35 minutes per child, which was pushing the children’s limits. For these two reasons, only the four motor-enhanced test items were administered.

Test Items

Hammill *et al.* (1993) provided the following descriptions of the test items related to visual motor integration:

1. Spatial relations

A grid of evenly spaced dots with lines connecting some of the dots to form a pattern, are shown to the children. They are then directed to a blank grid where they have to copy the pattern of the first grid.

2. Eye-hand coordination

The child is required to draw a line between two black lines without touching them; as difficulty increases the lines become narrower with curves and angles.

2. Copying

Children are shown a simple figure and asked to draw (copy) it in the empty square next to the stimulus figure. Figures become increasingly complex at the end.

3. Visual-motor speed

The child is presented with different shapes and the task is to draw lines in as many as possible appropriate designs within a set time.

Hammill *et al.* (1993) classified the tests of eye-hand coordination and spatial relations as indicators of the visual perception of spatial relations, which is the child's ability to see and analyse forms and patterns in relation to his/her own body and to space (p. 2). They classified the test of copying and visual-motor speed as indicators of the visual perception of form constancy, which is the child's ability to recognise the dominant features of objects when they appear in different sizes, positions, etc. (p. 2).

Scores on the DTVP-2

The scoring of the DTV P-2 supports interpretation of the test results in three different ways (Hammill *et al*., 1993):

1. All eight test results together to arrive at a comprehensive score of a child's visual perception.

2. A visual perception quotient only (MRPQ) based only on the composite score from the four motor-reduced tasks.

3. A visual motor integration quotient (VMIQ) based only on the composite score from the four motor-enhanced tasks.

For the purpose of this study, the individual scores from each of the motor-enhanced test items were converted to standard scores and percentiles as provided by the DTVP-2 test manual (Hammill *et al.*, 1993). This allowed the investigator to track any changes in a test item's performance during the study. A single composite score was also calculated based on the sum of the four scores. This is expressed as the visual motor integration quotient (VMIQ). As seen in Table 3, a rating scale is also provided in the manual to assist with the interpretation of the scores.

Table 3

DTVP-2 (VMI) rating scale for the interpretation of quotients and percentiles

Standard Scores	Descriptive Rating	Quotients
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

Procedures

The following sections describe the procedures that were followed in this study, from selection of participants to the retention testing.

Selection of Participants

As seen in the proposal in Appendix B, the headmaster of a private primary school in the Western Cape was contacted and requested to read through the proposal and background on the proposed study. After discussing the proposal with his physical education staff, he invited the investigator to conduct the research at his school.

Identification of Candidates

Two physical education teachers volunteered to identify children from Grade 1 and Grade 2 who they observed to be lagging behind their peers in terms motor proficiency. The both received a detailed information sheet regarding the study (Appendix C). Both were familiar with DCD and were looking specifically for “clumsiness” and/or other signs of DCD. They identified 22 children as possible candidates for the research project. This reliance on the initial judgment of professionals who were quite familiar with all the children and their motor proficiency was consistent with the recommendations of Miyahara and Wafer (2004). They noted that normative tests do not always identify children with coordination difficulties, and that the clinical judgment of professionals must also be regarded as a valid option.

Permission was then asked from their parents to allow them to participate in a screening session which consisted of the gross motor items of the M-ABC for Age Band Two. All parents agreed, at which time the children were asked if they would be willing to take the tests as part of a screening process. They all indicated that they were willing to take the tests.

The screening tests were taken during the physical education class in the school hall, during school hours at the end of the first term. The children wore sports clothes and the test was administered on an individual basis by the investigator and a qualified assistant. Only the gross motor test items were administered and all the test procedures were adhered to as it described in the M-ABC test manual.

Selection of Participants

After the results were calculated, 8 children were selected for the intervention programme and handed consent forms. The nature of the study was explained to each of them and written consent was granted by their parents for them to participate.

The research group initially consisted out of eight children (N=8), seven boys and one girl, between the ages of 7 and 8 years. After three weeks of the intervention programme the investigator was forced to drop one of the children because he was absent for one of the lessons. Therefore only seven children finished the programme (N=7), six boys and one girl. They were assigned fictitious names at this point and were referred to by those names on all forms, scorecards and logs kept during this study. Their ages, genders and grade levels are presented in Table 4.

Table 4

An outline of the participants in the study

Participants	**Age**	**Gender**	**Grade**
Mark	8	Male	2
Lisa	8	Female	2
James	8	Male	2
Luke	7	Male	1
Tom	8	Male	2
Peter	7	Male	1
Daniel	7	Male	1

Pre-test

After the screening test of 22 children on the gross motor items of the M-ABC, an initial group of eight subjects was selected for invitation to participate in the intervention programme. Informed consent forms were sent to their parents along with a written description of the study (see Appendix D). All parents returned the signed forms and encouraged their children to participate in the study. The children all then agreed.

While the screening M-ABC test results served as the pre-test, the eight children then also completed the motor-enhanced items on the DTVP-2 test. The tests were administered in a comfortable venue that was conducive to the pencil-and-paper tests. The items were all administered to each participant individually, by a test administrator who had previous experience with the DTVP-2. This test session lasted approximately 35 minutes per child. The score sheets for all participants on both the initial M-ABC and the DTVP-2 were then stored in a secure cabinet.

Intervention Programme

The perceptual-motor intervention programme was conducted over a period of six weeks and consisted of 45 minutes each week.

Programme Content

The programme was designed to focus on gross motor and visual motor integration skills. The investigator designed a content framework that was used to guide the development of practice activities (see Figure 3). An example of a lesson plan can also be seen in Appendix E. The purpose of the framework was to ensure that the practice sessions systematically encouraged the development of gross motor skills in activities that also challenged visual abilities. Although the full framework was not explored during this study, the premise of the framework was that every practice activity would focus on at least one gross motor skill and one visual ability. The practice activity would then be modified progressively by six different performance variables:

1. Vestibular stimulation
2. Time/Speed
3. Force

4. Relationship to the environment

5. Relationship to equipment

6. Attention Demands (distractions)

The practice activities offered in the intervention programme were dominated by challenges to eye-hand coordination in tasks of throwing and catching using a rebound net and a variety of different objects. Examples of the different types of activities performed on the rebound-net are included in Appendix F. The rebound net was specifically chosen as the central piece of apparatus in the intervention programme because of its constant challenge to visual-motor integration with gross motor skill performance.

Programme Characteristics

All sessions were designed as group sessions of not more than four children per group. In order to participate in this study, children had to participate in all practice sessions. Pless and Carlsson (2000) suggested that more research should be done using a group motor skill intervention programme with children with DCD. It was their belief that peer involvement could have a positive effect on the attractiveness of intervention programmes by providing the children with opportunities for social play interaction. An example of a lesson plan

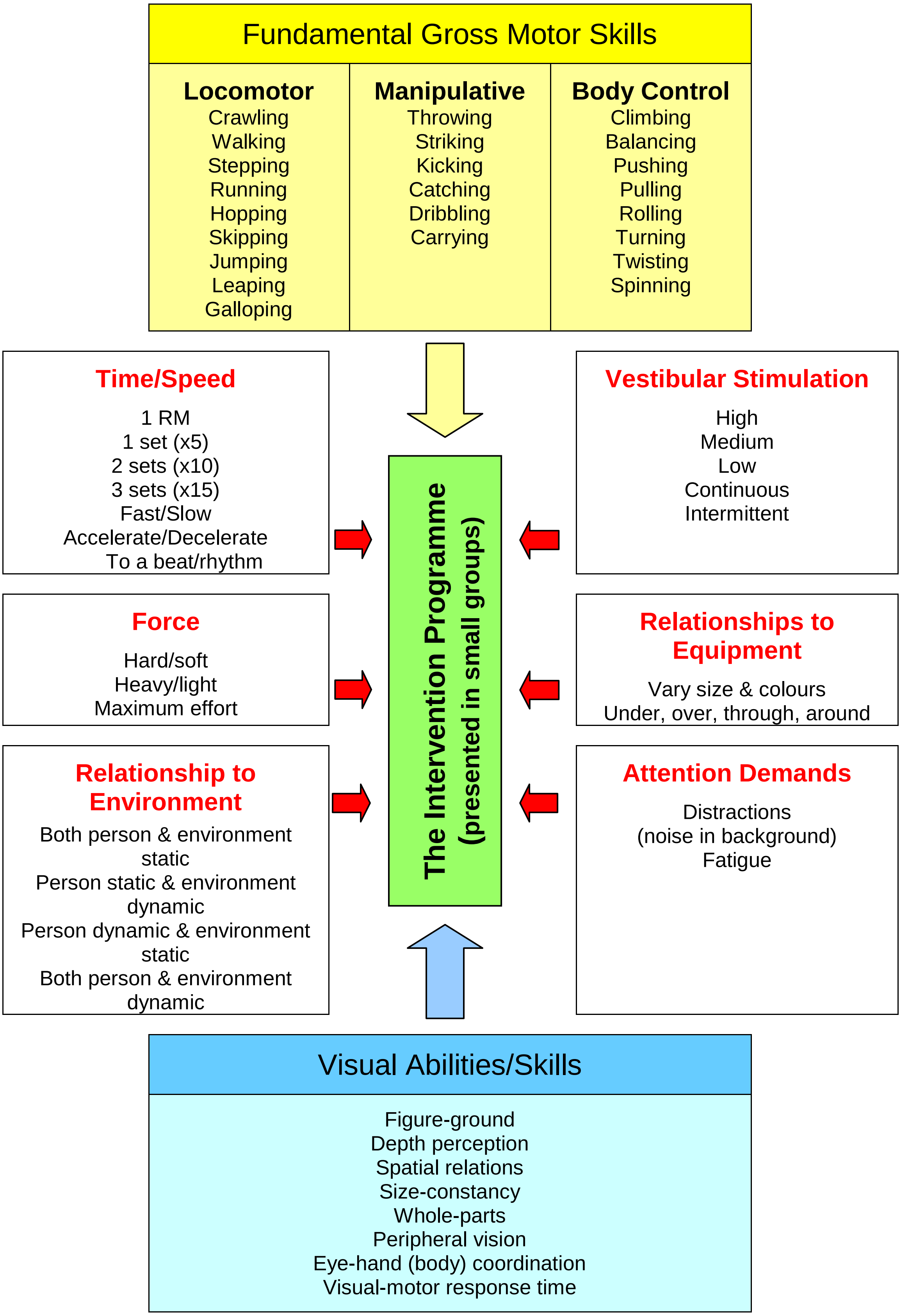

Figure 3. The perceptual-motor content framework from which each lesson was designed.

Although the children were taught in a small group, the use of the nets meant that the children would either take turns or have their own net on which to practice. This allowed the investigator to modify most activities to fit the needs of the individual children.

Post-test

The M-ABC and DTVP-2 assessments for each of the seven (N=7) subjects were completed immediately following the last practice session in their six-week intervention programme. One participant was dropped from the programme after being absent in the third week. Testing took place at the same venue as the pre-testing and was once again administered by the investigator and an experienced assistant.

Retention Test

Eight weeks after the post-tests, the M-ABC and DTVP-2 assessments were re-administered following the same protocol at the same venue by the same investigator and experienced assistant.

De-briefing of Participants

After the retention tests, each child was interviewed regarding his/her feelings about participation in the programme. The interview consisted of a series of questions and was conducted by the investigator in a quite and private venue (see Appendix G). The interview was recorded to ensure accuracy in reporting the outcomes. The interview also gave the investigator time to thank each child for participating in the programme.

Feedback about each child’s participation in the programme was provided to the teachers of the subjects involved, as well as to the headmaster of the school. A written letter summarising the results for each child was sent to his/her parents.

Treatment of the Data

The results of this study were presented individually for each child. The quantitative data from the M-ABC and DTVP-2 assessments were converted to standard scores and then processed according to the directions provided in the relevant test manuals. This allowed the investigator to graph the progress of each child on both selected gross motor skills and the tests of visual abilities from the pre- to the post- to the retention test periods. Qualitative data from both the interviews with the children and from the investigator’s log were reported in paragraph form on a child-by-child basis.

Summary

The purpose of the study was to evaluate the effects of a perceptual-motor training programme on children who show signs of DCD. A case study approach was taken in which seven children participated as members of a small group (one group of three children and another group of four children). Changes in their performance on the gross motor items of the M-ABC and the motor-enhanced items of the DTVP-2 were tracked from the pre-test to the post-test to the retention test. The children’s personal reports of their experiences in the programme were gathered in individual interviews. These results are presented in the following chapter.

Chapter Four

Results

The following chapter is divided to answer the research questions in relation to each case study separately. A discussion of the results is presented in Chapter Five.

Case Study One: Mark

Mark was an eight year old boy who is right-hand dominant. He was quite tall for his age which created the impression that he moved awkwardly. He was confident when performing skills involving a ball and eye-hand coordination, probably because he enjoyed playing with a ball and was successful at it. His balance skills were not good and he did not enjoy balance activities (often not really trying).

In general, Mark was willing to try new activities and seemed to gain a lot of confidence when he was successful. However, when he failed at something he would often give-up and refuses to try again, appearing to be very frustrated with himself. Mark had poor language skills, and it was sometimes difficult to understand what he was saying. He also tended to make funny noises. Despite these poor language skills, he was talkative to the point where he seemed to distract himself as well as disturb the class. Although he was turning nine at the end of the year he was only still in Grade 2, therefore chronologically a year ahead of his classmates.

Research Question One

1. What were the effects of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?

The results of the fives tests of gross motor proficiency (both raw scores and standard scores) on the M-ABC were used to determine the impact of the programme on Mark. No changes were found in either his eye-hand coordination or his dynamic balance, but these were areas in which his raw scores were quite high or maximum for the test item. The conversion to standard M-ABC scores also indicated that he had no coordination difficulties in these areas, although there was room for improvement of his raw scores on the test of aiming. However, both the raw scores and the standard scores for static balance showed a very good improvement which was sustained on the retention test. It can be concluded that the programme had a positive influence on Mark's static balance.

Results for Eye-hand Coordination

Two tests assessed eye-hand coordination and Mark showed quite consistent results. On the pre-test he scored 7, on the post-test 8 and on the retention test 7 again.

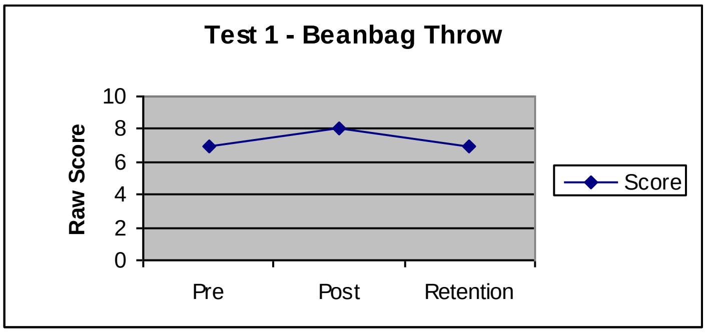

Figure 4. *Raw Scores on the beanbag throw (aiming).*

When Mark's raw scores were converted to standard scores (between 0 and 5), he achieved a 0 for each test opportunity (see Figure 5). These results indicate that for his age, he is not considered to have coordination problems on this test of eye-hand coordination (aiming).

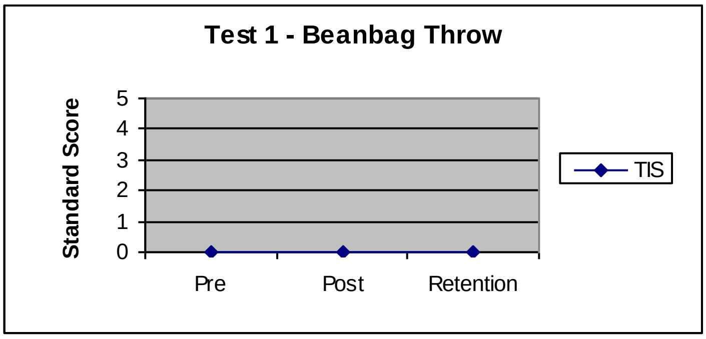

Figure 5. *M-ABC standard score on the beanbag throw (aiming).*

Mark showed good eye-hand coordination skills in the one-hand bounce and catch test, catching all 10 balls possible with each hand individually, on all three test-occasions (see Figure 6). This was a good and consistent performance with both his non-preferred and preferred hands.

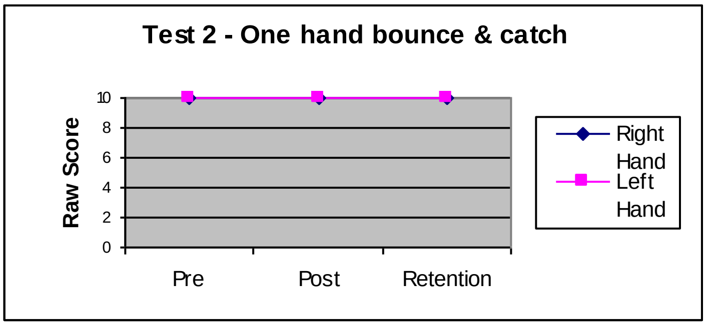

Figure 6. *Raw Scores on the bounce and catch test for right and left hand (coincident timing).*

Achieving full marks on all three test opportunities for both hands converted to standard scores of 0, indicating that Mark had no coordination problems in this area for his age (see Figure 7).

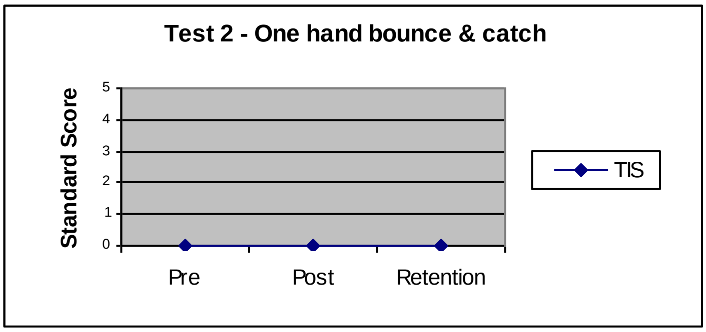

Figure 7. *M-ABC standard scores on the bounce and catch test for right and left hand (coincident timing).*

Dynamic Balance

Mark did well in both the dynamic balance tests. He completed 5 out of 5 jumps in the squares of the ladder on all three test occasions (see Figure 8).

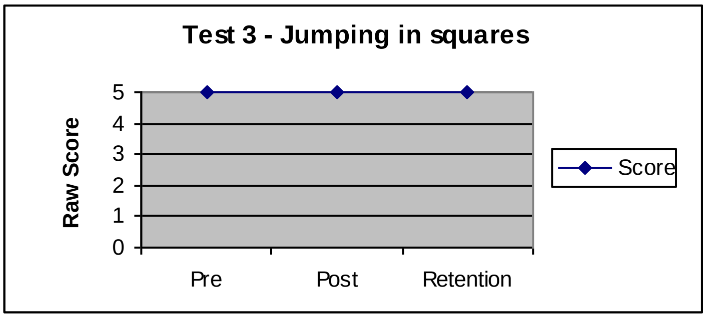

Figure 8. *Raw Scores on the jumping in squares test (dynamic balance).*

Mark's raw score converted to a standard score of 0 which indicated he had no coordination difficulties with this measure of dynamic balance for someone his age (see Figure 9).

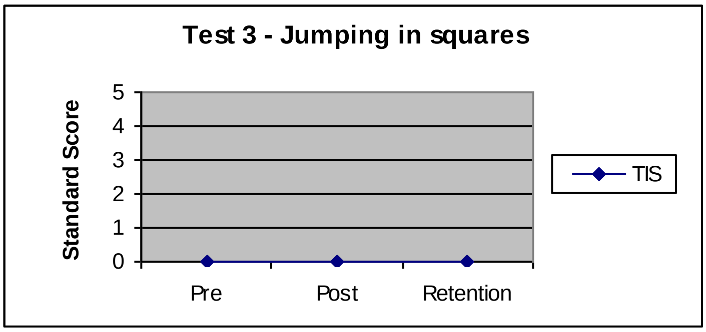

Figure 9. *M-ABC standard scores on the jumping in squares test (dynamic balance).*

On the heel-toe walking test, Mark once again showed good dynamic balance. He earned raw scores of 15 on all three test-occasions with zero number of errors (see Figure 10).

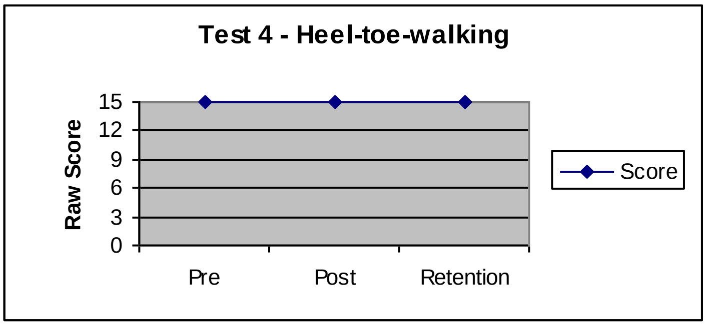

Figure 10. *Raw Scores on the heel-toe walking test (dynamic balance).*

When converted to a standard score, Mark earned a 0 on all three test occasions, indicating no dynamic balance problems for a person his age.

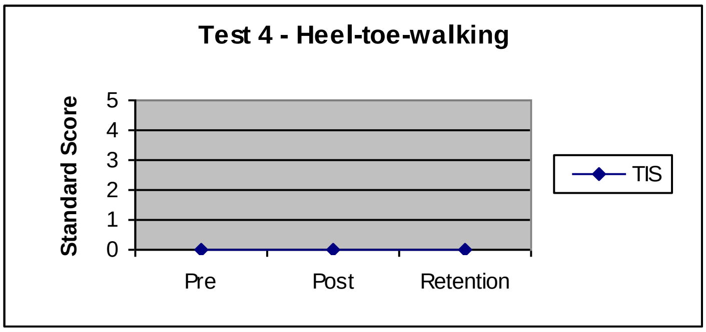

Figure 11. *M-ABC standard scores on the heel-toe walking test (dynamic balance).*

Static Balance

In the test of static balance, Mark showed a substantial improvement for both his left and right legs from the pre-test to post-test, and he was able to sustain these improvements on the retention test (see Figure 12). On the pre-test, he could only balance for 7 seconds on each leg, but he improved that performance to 20 seconds on the post-test and the retention test.

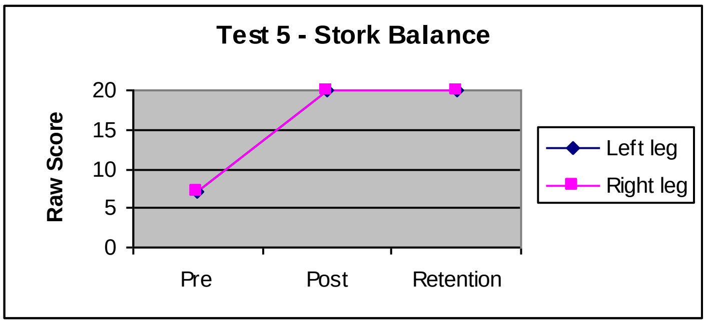

Figure 12. *Raw Scores on the stork balance test (static balance).*

As shown in Figure 13, Mark's pre-test standard scores of 3 indicated that he has some mild problems with his static balance. However, his improvements converted to standard scores of 0 on both the post-test and the retention test. This took him to the category of no problems with static balance for a person of his age, following his participation in the intervention programme.

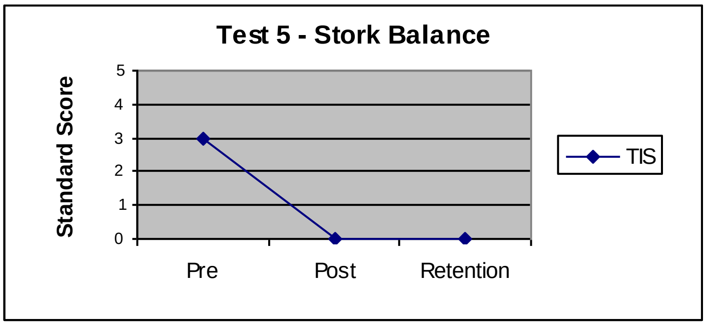

Figure 13. *M-ABC standard scores on the stork balance test (static balance).*

Research Question Two

2. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual motor integration abilities of children who show signs of DCD?

The results of the four tests of visual perception that assess visual motor integration from the DTVP-2 were used to determine the impact of the programme on Mark. He showed improvements in both his eye-hand coordination and visual-motor speed after participation in the intervention programme. There was no change in his copying scores. It was only in spatial relations that his test performance deteriorated. When the quotient score that integrates the results of all four tests is considered, Mark's VMI was rated as below average on the pre-, post- and retention tests. This suggests that although there were improvements in eye-hand coordination and visual-motor speed, the intervention programme did not have an effect on his overall VMI. The standard scores for Mark's performance on each of the four variables (pre-test, post-test and retention test) are presented in Figure 14.

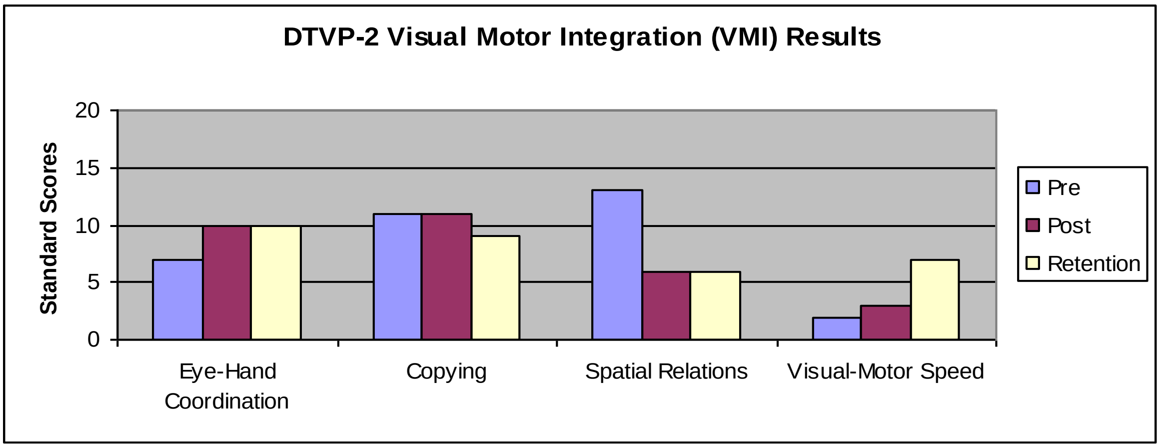

Figure 14. *DTVP-2 (VMI) pre-, post- and retention test standard scores.*

Standard Scores

Standard scores allow the results from the different tests to be compared to each other in order get an integrated picture of Mark's performance in terms of

VMI. Table 5 presents the sums of the standard scores, and then the conversion of the sums into composite scores. The interpretation of these values into a kind of rating scale is provided in Table 6 and allows a holistic assessment of Mark's progress in terms of visual-motor integration.

Table 5

DTVP-2 (VMI) Pre-, Post-, Retention test and Composite Scores

Subtests (VMI)	**Standard Scores**		
	Pre	Post	Retention
Eye-Hand Coordination	7	10	10
Copying	11	11	9
Spatial Relations	13	6	6
Visual-Motor Speed	2	3	7
Standard scores total	**33**	**30**	**32**
Percentile	**21**	**13**	**19**
Quotient	**88**	**83**	**87**

Table 6

DTVP-2 (VMI) rating scale for the interpretation of quotients and percentiles

Standard Scores	**Descriptive Rating**	**Quotients**
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

According to the standard scores that Mark earned on the individual test items, the following results can be noted:

- Eye-hand coordination improved from the below average category to the average category with his pre-test score of 7 climbing to 10 on the post-test, which was maintained on the retention test.

- Scores for copying were 11 on the pre-test, 11 on the post-test and 9 on the retention test, all of which kept his rating in the average category.

- The decrease in his score on spatial relations from 13 to 6 on both the post-test and retention test dropped Mark’s ratings in this category from the above average group to below average.

- His scores for visual-motor speed improved from 2 on the pre-test to 3 on the post-test and then 7 on the retention test. These results shifted his rating from very poor to below average for visual-motor speed.

Percentile Scores

Percentile scores allow the comparison between Mark’s performance and the performances of other children his age. Table 7 presents his scores on the VMI tests of the DTVP-2 converted to percentiles (his position relative to other children of his age).

- His eye-hand coordination performance improved from the 16th percentile on the pre-test to the 50th percentile on the post-test, an improvement that was maintained on the retention test.

- Mark’s results for copying placed him in the 63rd percentile on both the pre-test and post-test, but he dropped to the 37th percentile on the retention-test.

- His pre- and post-test performance put him in the 1st percentile. His higher score on the retention test converted to the 9th percentile.

- The pattern of his scores for visual-motor speed also showed the lowest score possible on both the pre-test (less than the 1st percentile) and post-test (1st percentile). His score on the retention-test converted to the 16th percentile.

Table 7

The conversion of Mark's VMI (DTVP-2) standard scores to percentiles

Subtests (VMI)	**Pre-test Percentile**	**Post-test Percentile**	**Retention test Percentile**
Eye-hand coordination	16	50	50
Copying	63	63	37
Spatial relations	1	9	9
Visual-motor speed	‹1	1	16
Total Percentile Ranking	**21**	**13**	**19**

Composite Quotients

According to the DTVP-2 test manual (Hammill *et al.,* 1993) the composite quotient score is the most reliable result to use when interpreting results for a child in order to track changes in his/her integrated VMI performance (all four variables taken into account). The quotient scores for Mark are presented in Figure 15. Mark's pre-test quotient score was 88. It decreased to 83 for the post-test and then went up to 87 again on the retention test. Despite the apparent changes, Mark's performances were in the below average category on each test occasion.

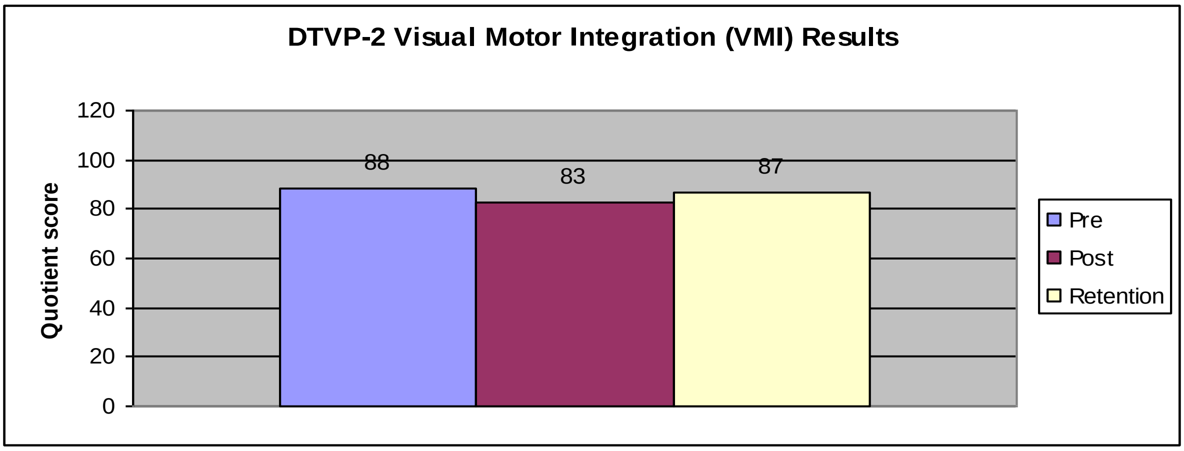

Figure 15. *VMI (DTVP-2) pre-, post- and retention test quotients.*

Research Question Three

3. How did the children feel about their participation in the small group-based intervention programme?

At a separate and individual interview session following the retention test, Mark answered several questions about how he experienced the intervention programme. He indicated he enjoyed the programme, but would probably not want to do it again.

Content of the Programme

Mark was asked what specifically he could recall about the activities in the programme, if he felt that he learned anything new, and if it was easier to do the activities toward the end of the programme. He remembered the games they played on the nets with the beanbags and thought that the activities definitely easier for him at the end of the programme. He said that he learned to keep eye-contact with the ball when throwing and catching.

Structure of the Lessons

He was asked if he enjoyed the small group sessions or if he would have preferred individual sessions. He was also asked if he can remember the other children in his group. He said that he liked the small group and preferred it to individual sessions. He also remembered that Lisa, James and Tom were in his group.

Overall Evaluation of the Programme

In terms of his overall evaluation of the programme, Mark said that he enjoyed the one-hand throwing and catching the most because he got it right. He did not like balancing on the one leg because he struggled with it. He also said that he would not really want to do the programme again because he sometimes got cramps in his legs.

Mark claimed to have done all is homework with his mother assisting him, and again stated that he learned a lot but would not really want to do the programme again.

Post-programme Comments about Mark

Mark struggled to listen whenever directions for activities were given, which meant that sometimes he was unsure of what to do. He also tended to distract his fellow classmates with his constant talking and by making noises. This made the investigator wonder if he might be showing signs of co-morbid ADHD (his lack of concentration and short attention-span) or Asperger syndrome (the constant noises he makes and the blowing of bubbles). Mark adapted well to the programme and showed some good skill and progression in certain areas like the one hand bounce-and-catch. He was always excited about playing on the rebound nets and portrayed good self-confidence at times.

Case Study Two: Lisa

Lisa was eight years old during the intervention programme but turned nine at the end of her Grade 2 year. She meant that she was approximately 8-10 months older than the rest of her classmates. One possible outcome of this difference was that she was much taller than most of them. Lisa showed good self-discipline and listening skills in class. When she did not understand what she expected to do, she asked questions for clarity. Her verbal skills were excellent. She usually took a leadership role in small group work by organising and explaining tasks to the others. She was always eager to be first in line and to show you when she succeeded.

Her verbal and social development was not matched by her motor performance. She struggled to catch a ball or stand on one leg. She clearly understood what was expected of her in movement situations, which suggested that her cognitive processing was satisfactory although her motor performance was described by her physical education teachers as clumsy. It was also clear how her lack of success in movement situations frustrated her. She became “teary” at times when she failed to be successful. Sometimes, she even came up with excuses to avoid participation entirely, such as she was “too tired” to participate

Research Question One

1. What were effects of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?

The results of the fives tests of gross motor proficiency (both raw scores and standard scores) on the M-ABC were used to determine the impact of the programme on Lisa’s motor proficiency. No changes were found in either the raw and standard scores of the dynamic balance tests, but these were areas in which her pre-test scores were quite high or maximum for the test items. The conversion to standard M-ABC scores indicated that she did not have eye-hand coordination difficulties, although there was room for improvement of her raw scores on the test of aiming. Both the raw scores and the standard scores for static balance showed a good improvement from the pre-test to the post-test, and that the improvements were sustained on the retention test. It can be concluded that the programme had a positive influence on Lisa's static balance and eye-hand coordination.

Results for Eye-hand Coordination

Raw scores for Lisa on the beanbag throwing test for accuracy were 7 out of 10 in the box on the pre-test, 6 out of 10 on the post-test and 9 out of 10 on the retention test. This improvement can be seen in Figure 16.

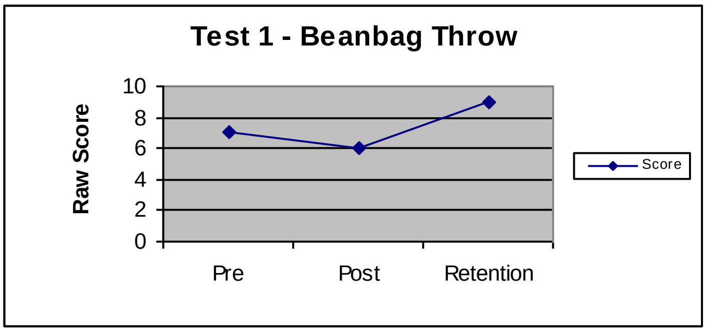

Figure 16. *Raw scores on the beanbag throw (aiming).*

When converting the raw scores of Figure 16 to standard scores (between 0 and 5), Lisa achieved a standard score of 0 on all three test-occasions (see Figure 17). Although the range for achieving a standard score of 0 is quite generous (between 6-10 throws all earn a standard of 0), she was not considered to have coordination problems on this test of eye-hand coordination (aiming).

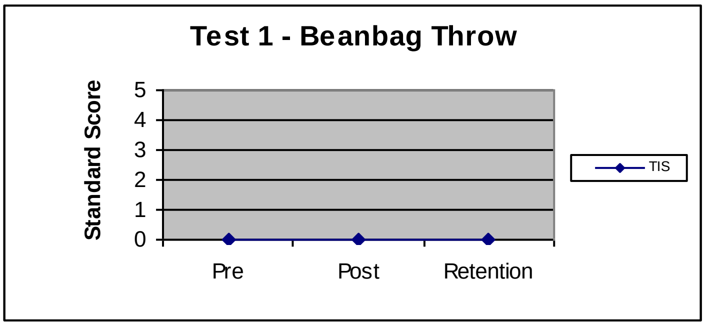

Figure 17. *M-ABC standard scores on the beanbag throw (aiming).*

Lisa had quite similar results with both her left and her right hand on the one-hand bounce and catch tests (see Figure 18). With the right hand (her preferred hand) she scored 10 on the pre-test, 9 on the post-test and 10 on the retention test. With her non-preferred hand (her left hand), she scored 8 on the pre-test, and 10 on both the post-test and the retention test.

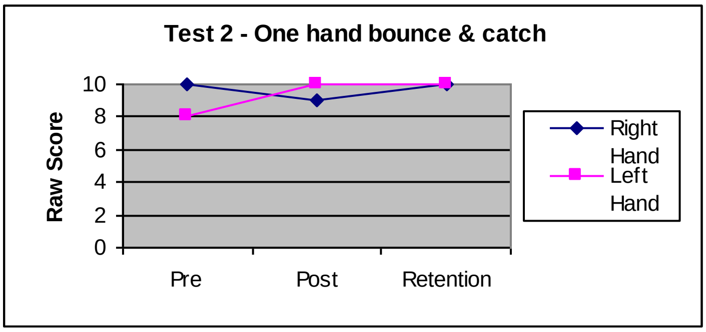

Figure 18. *Raw Scores on the bounce and catch test for right and left hand (coincident timing).*

When calculating the standard score on this test, the raw scores from both the left and right hands are added together and a mean score is then determined. The mean is then converted to a standard score. The standard score for Lisa on this test of eye-hand coordination (coincident timing) was 0.5 on the pre-test, 0.5 on the post-test and 0 on the retention test. These scores indicated that Lisa had no coordination problems in this area for a child her age.

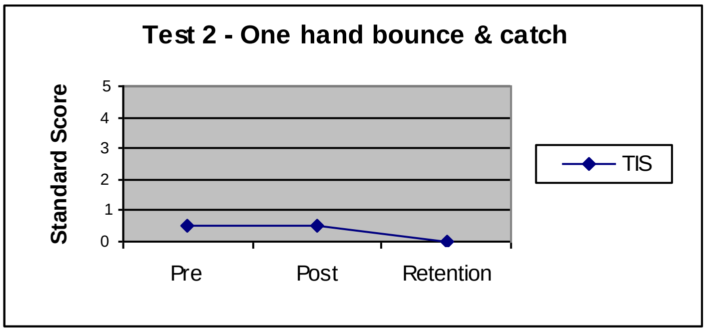

Figure 19. *M-ABC standard scores on the bounce and catch test for right and left hand (coincident timing).*

Dynamic Balance

Lisa did well on both the dynamic balance tests. She completed 5 out of 5 jumps in the squares of the ladder on all three test occasions (see Figure 20).

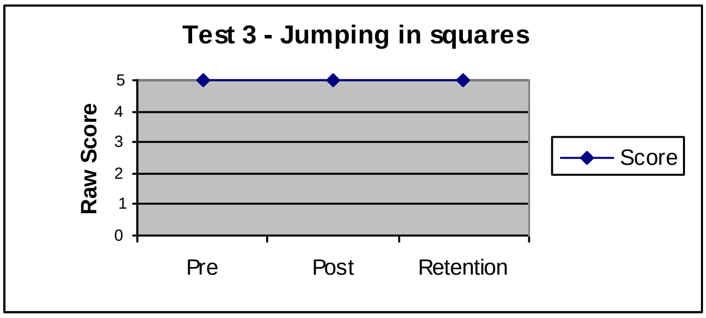

Figure 20. *Raw Scores on the jumping in squares test (dynamic balance).*

Lara's raw scores of five were converted to standard scores of 0 Lisa on all three tests (see Figure 21). This indicated that she had no coordination difficulties with this measure of dynamic balance for someone her age.

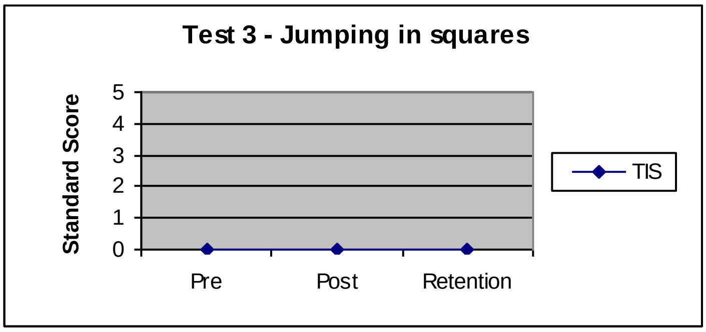

Figure 21. *M-ABC standard scores on the jumping in squares test (dynamic balance).*

On the heel-toe walking test, Lisa once again showed good dynamic balance. She earned raw scores of 15 on all three test-occasions with 0 errors (see Figure 22).

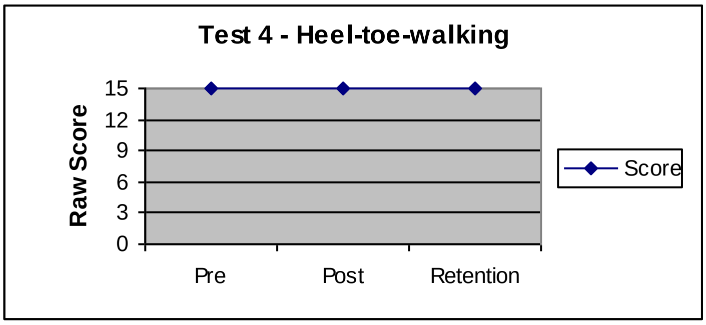

Figure 22. *Raw Scores on the heel-toe-walking test (dynamic balance).*

When converted to a standard score, Lisa earned 0 on all three test occasions as shown in Figure 23, indicating no dynamic balance problems for a person her age.

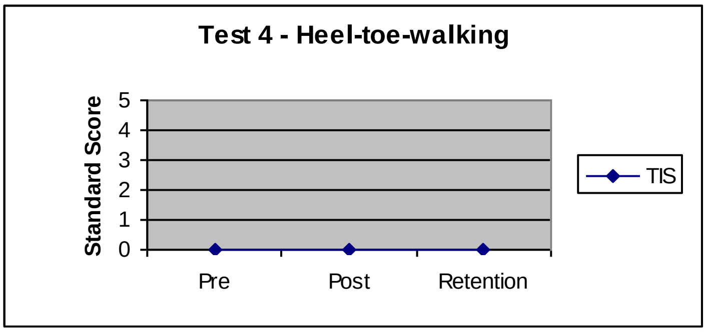

Figure 23. *M-ABC standard scores on the heel-toe-walking test (dynamic balance).*

Static Balance

In the test of static balance, Lisa showed a substantial improvement for both her left and right legs from the pre-test to post-test, and she was able to sustain these improvements on the retention test (see Figure 24). On the pre-test, she could only balance for 9 and 12 seconds respectively on her right and left legs, but she improved that performance to 20 seconds on both the right and the left legs on the retention test.

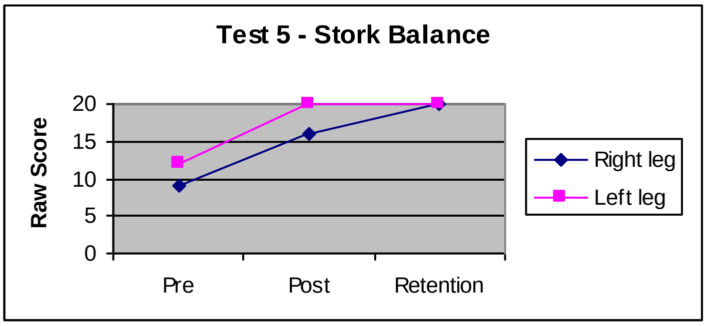

Figure 24. *Raw Scores on the stork balance test (static balance).*

As shown in Figure 25, Lisa's pre-test standard scores of 1.5 indicated that he has some mild problems with her static balance. However, her improvements converted to standard scores of 0 on both the post-test and retention test. This took her to the category of no problems with static balance for a child her age, following his participation in the intervention programme.

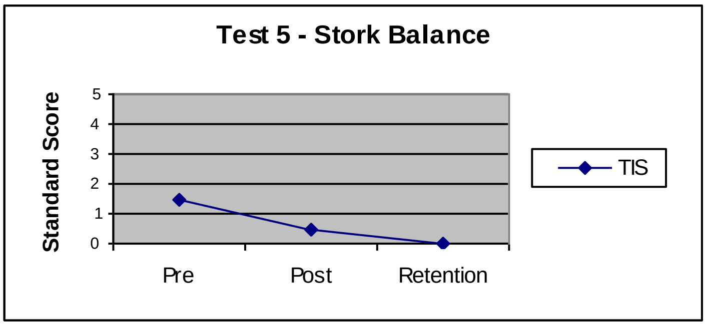

Figure 25. *M-ABC standard scores on the stork balance test (static balance).*

Research Question Two

2. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual-motor integration abilities of children who show signs of DCD?

The results of the four tests of visual perception that assess visual motor integration from the DTVP-2 were used to determine the impact of the programme on Lisa. She showed improvements in eye-hand coordination, copying and spatial relations after participation in the intervention programme. There was no improvement in her visual-motor speed score and in fact, her score deteriorated. When the quotient score that integrates the results of all four tests is considered, Lisa's VMI was rated as average on the pre-, post- and retention tests. This suggests that although there were improvements in her eye-hand coordination, copying and spatial relations scores, the intervention programme did not have an effect on her overall VMI. The standard scores for Lisa's performance on each of the four variables (pre-test, post-test and retention test) are presented in Figure 26.

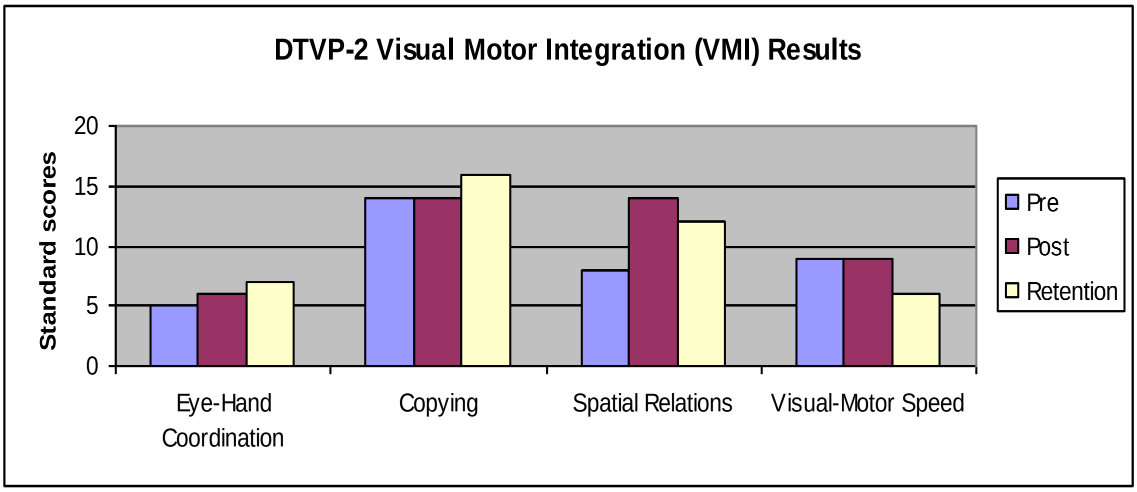

Figure 26. *DTVP-2 (VMI) pre-, post- and retention test standard scores.*

Standard Scores

Standard scores allow the results from the different tests to be compared to each other in order get an integrated picture of Lisa's performance in terms of VMI. Table 8 presents the sums of the standard scores and then the conversion of the sums into composite scores. The interpretation of these values into a kind of rating scale is provided in Table 9 and allows a holistic assessment of Lisa’s progress in terms of visual-motor integration.

Table 8

DTVP-2 (VMI) Pre-, Post-, Retention test and Composite Scores

Subtests (VMI)	**Standard Scores**		
	Pre	Post	Retention
Eye-Hand Coordination	5	6	7
Copying	14	14	16
Spatial Relations	8	14	12
Visual-Motor Speed	9	9	6
Standard scores total	**36**	**43**	**41**
Percentile	**32**	**63**	**55**
Quotient	**93**	**105**	**102**

Table 9

DTVP-2 (VMI) rating scale for the interpretation of quotients and percentiles

Standard Scores	**Descriptive Rating**	**Quotients**
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

According to the standard scores that Lisa earned on the individual test items, the following results can be noted:

- Eye-hand coordination improved from the poor category to the below average category with her pre-test score of 5 improving to 6 on the post-test and to 7 on the retention test.

- Scores for copying were 14 on the pre-test, 14 on the post-test and 16 on the retention test, which moved Lisa's performance from the above average category to the superior category on this item.

- The increase in her score on spatial relations from 8 on the pre-test to 14 on the retention test increased Lisa's ratings from the average category to the above average category, although her score dropped to 12 on the retention test.

- Her scores for visual-motor speed dropped from 9 on the pre- and the post-test to 6 on the retention test. These results shifted her rating from average to below average for visual-motor speed.

Percentile Scores

Percentile scores allow the comparison between Lisa's performance and the performances of other children her age. Table 10 presents her scores on the VMI tests of the DTVP-2 converted to percentiles (her position relative to other children of her age).

- Her eye-hand coordination performance improved from the 5th percentile on the pre-test to the 9th percentile on the post-test and the 16th percentile on retention test.

- Lisa's results for copying placed her in the 91st percentile on both the pre-test and post-test, and even higher on the retention test in the percentile of 98th.

- There was a substantial change in her percentile scores for spatial relations. Her pre-test performance was in the 25th percentile but she was able to record a much better score on the post-test which moved her to the 91st percentile. She was able to maintain her performance to the 75th percentile on the retention test.

- The pattern of her scores for visual-motor speed was initially higher with pre- and post-test scores in the 37th percentile, but her score on the retention test converted only to the 9th percentile.

Table 10

The conversion of Lisa's VMI (DTVP-2) standard scores to percentiles

Subtests (VMI)	**Pre-test Percentile**	**Post-test Percentile**	**Retention test Percentile**
Eye-hand coordination	5	9	16
Copying	91	91	98
Spatial relations	25	91	75
Visual-motor speed	37	37	9
Total Percentile Ranking	**32**	**63**	**55**

Composite Quotients

According to the DTVP-2 test manual (Hammill *et al.,* 1993*)* the composite quotient score is the most reliable result to use when interpreting results for a child in order to track changes in his/her integrated VMI performance. Lisa's pre-test quotient score was 93 (see Figure 27). It increased to 105 on the post-test and dropped slightly to 102 on the retention test. Despite the apparent changes, Lisa's performances were in the average category on each test occasion.

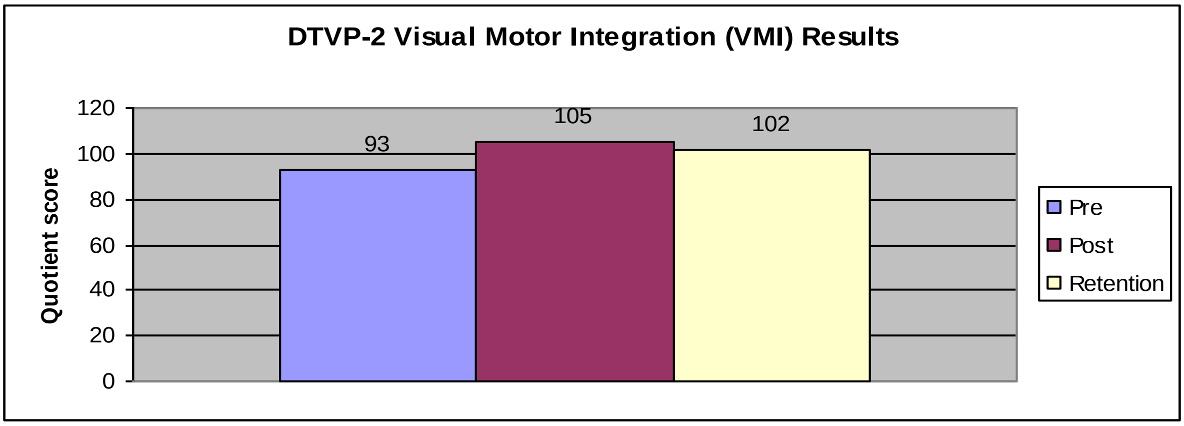

Figure 27. *VMI (DTVP-2) pre-, post- and retention test quotients.*

Research Question Three

3. How did the children feel about their participation in the small group-based intervention programme?

At a separate and individual interview session following the retention test, Lisa answered several questions about how she experienced the intervention programme. She indicated she enjoyed the programme and would definitely want to do it again.

Content of the Programme

Lisa was asked what specifically she could recall about the activities in the programme, if she felt that she learned anything new, and if it was easier to do the activities toward the end of the programme. Lisa remembered almost everything about the programme in detail. She remembered playing on the rebound nets, but also doing activities at different stations with ladders, balls, beanbags and the balancing activities. She felt that she learned to throw the beanbag better into the box. She also reported that the practice activities definitely became easier and that she became more successful toward the end of the programme.

Structure of the Lessons

She was asked if she enjoyed the small group sessions or if she would have preferred individual sessions. She was also asked if she could remember the other children in her group. She made it clear that she would prefer individual lessons next time, because in the group there was too much noise and she struggled to concentrate because the boys in her group were always “so busy” and distracted her. She remembered that Mark, James and Tom were in her group.

Overall Evaluation of the Programme

In terms of her overall evaluation of the programme, she said that she enjoyed the balancing and one-hand throwing and catching the most. She also had fun bouncing on the big Swiss ball and trying to maintain balance.

Lisa said there was nothing she did not enjoy and she definitely wanted to do the programme again because next time she wants to try and do everything even better, getting better scores and concentrating more. Lisa claimed to have done all her homework with her mother assisting her.

Post-programme Comments about Lisa

Lisa managed herself quite well socially and seemed to have gotten along with everyone in her group, although she was the only girl. She was definitely not shy. She did not show any delays in social, emotional or cognitive development.

Despite her proficiency in other domains, she definitely struggles with certain motor skills and there is a proficiency gap between her and most of her classmates, despite the fact that she is one of the oldest children in her class. According to Lisa's answers about participation in future the intervention programme it is clear that she has perfectionist tendencies. She always wants to try and do something better than the previous time. She asks intelligent questions and makes good observations. Her answer that she would prefer to practice on her own the next time was not because she felt pressure from the group but because she did not want any distractions while she concentrating so that she could give her best in each activity.

Case Study Three: James

James was an eight year old boy who was right hand dominant. He was of normal height and weight for his age. Although he struggled with the eye-hand coordination and static balance activities, he was very enthusiastic about participation in the intervention programme and always gave his best in each activity.

James appeared to have an introvert type of personality. He did not interact much with the others in his group as he often appeared to be self-conscious about his performance. He seemed to lack self-confidence and often turned to the investigator to get encouragement, approval and praise. Overall he could be described as a quiet boy who tried to get along with everyone.

James could be persistent and did not show signs of concentration problems or any other delays besides the motor coordination problems that his teacher had identified. James did get very frustrated and angry with himself when he struggled or failed to perform tasks successfully.

Research Question One

4. What were the effects of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?

The results of the fives tests of gross motor proficiency (both raw scores and standard scores) on the M-ABC were used to determine the impact of the programme on James. No changes were found in one of the tests of eye-hand coordination and in his dynamic balance. These were areas in which his raw scores were quite high or maximum for each test item. The conversion to standard M-ABC scores also indicated that he had no coordination difficulties in these areas, although there was room for improvement of his raw scores on the test of aiming. Both the raw scores and the standard scores for his eye-hand aiming and his static balance showed a very good improvement which was sustained on the retention test. It can be concluded that the programme had a positive influence on James' aiming and his static balance.

Results for Eye-hand Coordination

Two tests assessed eye-hand coordination and James showed a substantial improvement in the results of the first test that relies on aiming ability. On the pre-test of the beanbag throw, James was not successful with any of the ten throws. On the post-test however, he tossed 8 out of the 10 throws into the box, and on the retention test he achieved 6 out of 10 throws into the box. This can be seen in Figure 28.

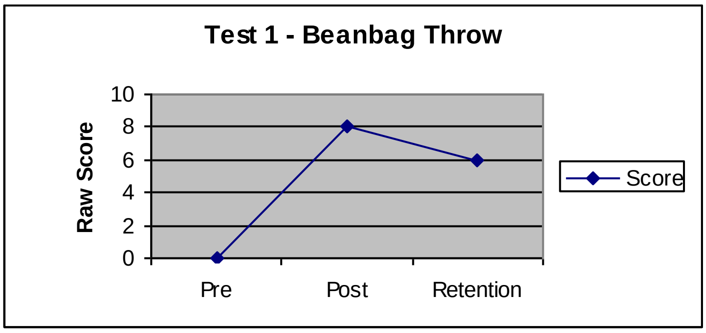

Figure 28. *Raw Scores on the beanbag throw (aiming).*

When James's raw scores were converted to standard scores (between 0 and 5), he achieved a 5 on the pre-test and a 0 for each of the other test opportunities (see Figure 29). These results indicate that for his age, he began showing severe signs of coordination problems, but by the end of the programme, no longer displace these problems with his eye-hand coordination (aiming).

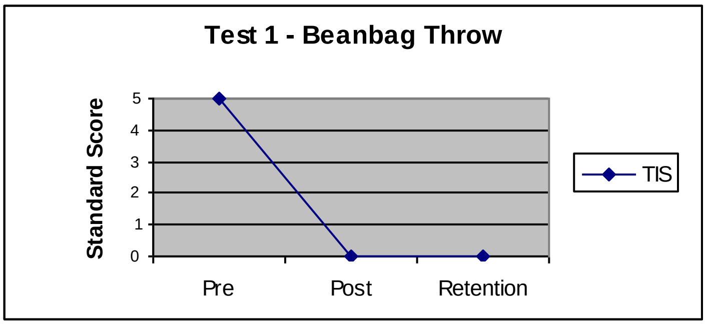

Figure 29. *M-ABC standard score on the beanbag throw (aiming).*

James showed good eye-hand coordination skills in the one-hand bounce and catch test, catching all 10 balls possible with each hand individually, on all three test-occasions (see Figure 30). This was a good and consistent performance with both his non-preferred hand and preferred hand.

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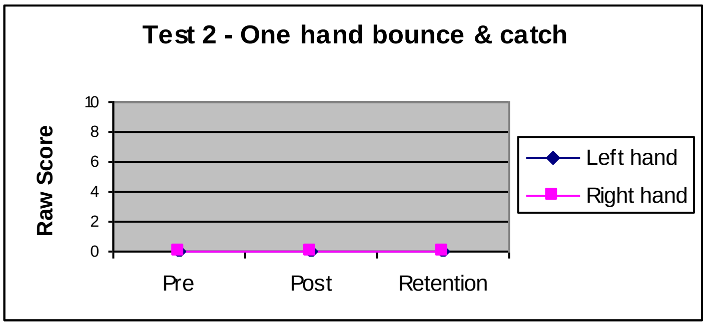

Figure 30. *Raw Scores on the bounce and catch test for right and left hand (coincident timing).*

Achieving full marks on all three test opportunities for both hands converted to standard scores of 0, indicating that James had no coordination problems in this area for his age (see Figure 31).

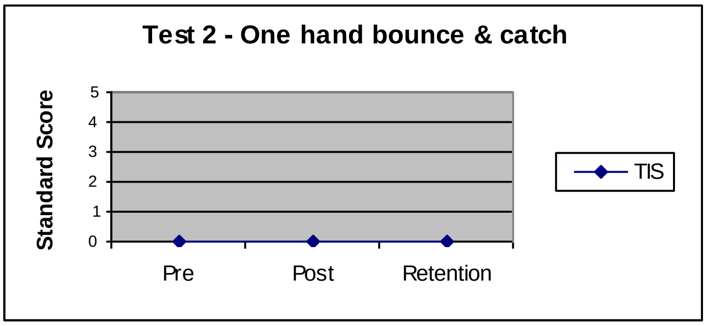

Figure 31. *M-ABC standard scores on the bounce and catch test for right and left hand (coincident timing).*

Dynamic Balance

James did well on both the dynamic balance tests. He completed 5 out of 5 jumps in the squares of the ladder on all three test occasions (see Figure 32).

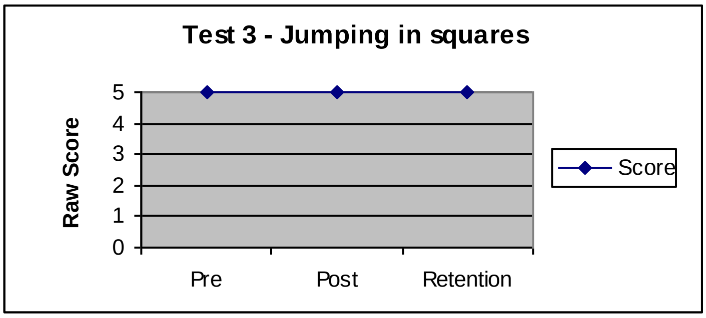

Figure 32. *Raw Scores on the jumping in squares test (dynamic balance).*

James's raw score converted to a standard score of 0 which indicated he had no coordination difficulties with this measure of dynamic balance for someone his age (see Figure 33).

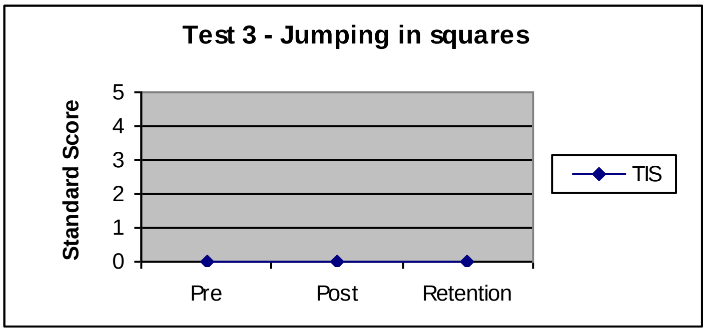

Figure 33. *M-ABC standard scores on the jumping in squares test (dynamic balance).*

On the heel-toe walking test, James once again showed good dynamic balance. He earned raw scores of 15 on all three test-occasions with zero numbers of errors (see Figure 34).

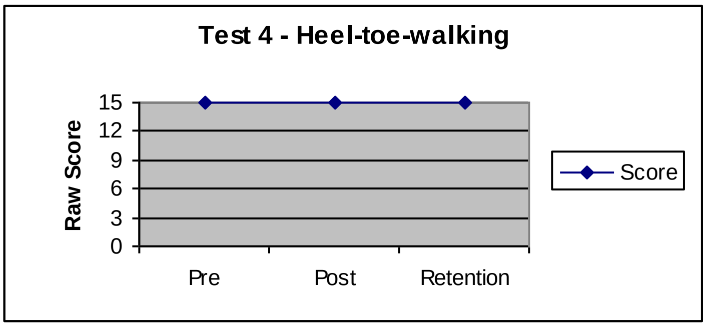

Figure 34. *Raw Scores on the heel-toe-walking test (dynamic balance).*

When converted to a standard score, James earned a 0 on all three test occasions, indicating no dynamic balance problems for a person his age.

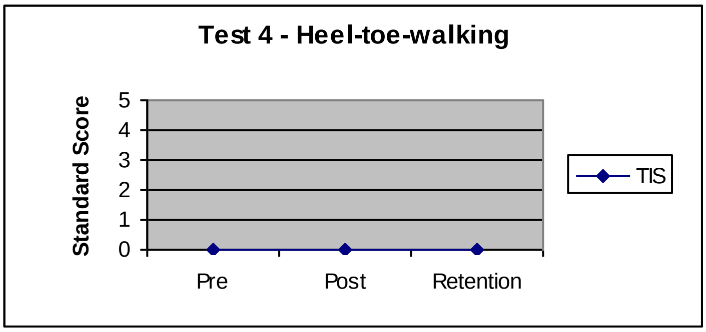

Figure 35. *M-ABC standard scores on the heel-toe walking test (dynamic balance).*

Static Balance

In the test of static balance, James showed a substantial improvement for both his left and right legs from the pre-test to post-test (see Figure 36). On the pre-test, he could only balance for 7 seconds on the right leg and 10 seconds on the left, but he improved that performance to 20 seconds on the post-test for both legs. Unfortunately he was unable to sustain these improvements on the retention-test, dropping back to 10 seconds on the right leg and 15 seconds on the left leg.

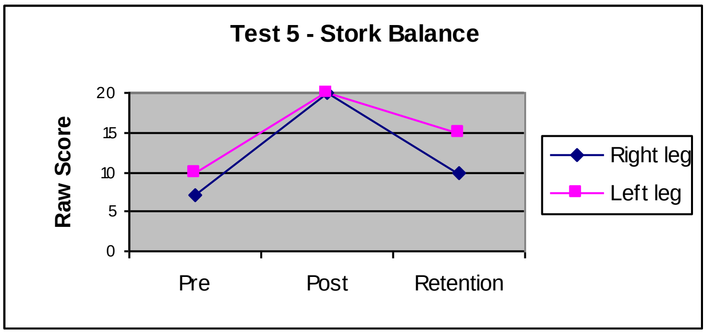

Figure 36. *Raw Scores on the stork balance test (static balance).*

As shown in Figure 37, James's pre-test standard score of 1.5 indicated that he has some mild problems with his static balance. However, his improvements converted to standard scores of 0 on the post-test and 0.5 on the retention test. This took him to the category of no problems with static balance for a person of his age, following his participation in the intervention programme.

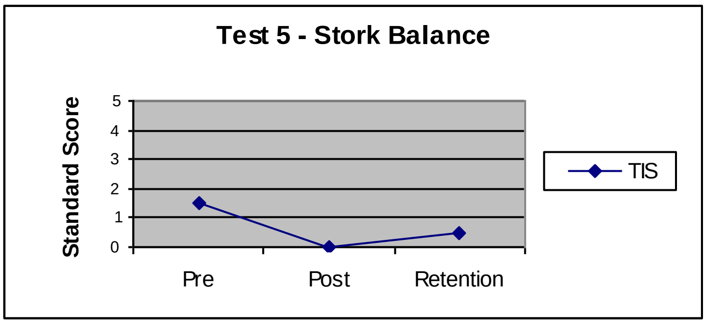

Figure 37. *M-ABC standard scores on the stork balance test (static balance).*

Research Question Two

5. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual-motor integration abilities of children who show signs of DCD?

The results of the four tests of visual perception that assess visual motor integration from the DTVP-2 were used to determine the impact of the programme on James. Although he showed improvements on all four tests after participation in the intervention programme, there was also a drop in all four scores from post-test to retention test. The biggest improvement was in eye-hand coordination. When the quotient score that integrates the results of all four tests is considered, James's VMI was rated as below average on the pre-test and average on both the post-test and retention test. The standard scores for James's performance on each of the four variables (pre-test, post-test and retention test) are presented in Figure 38.

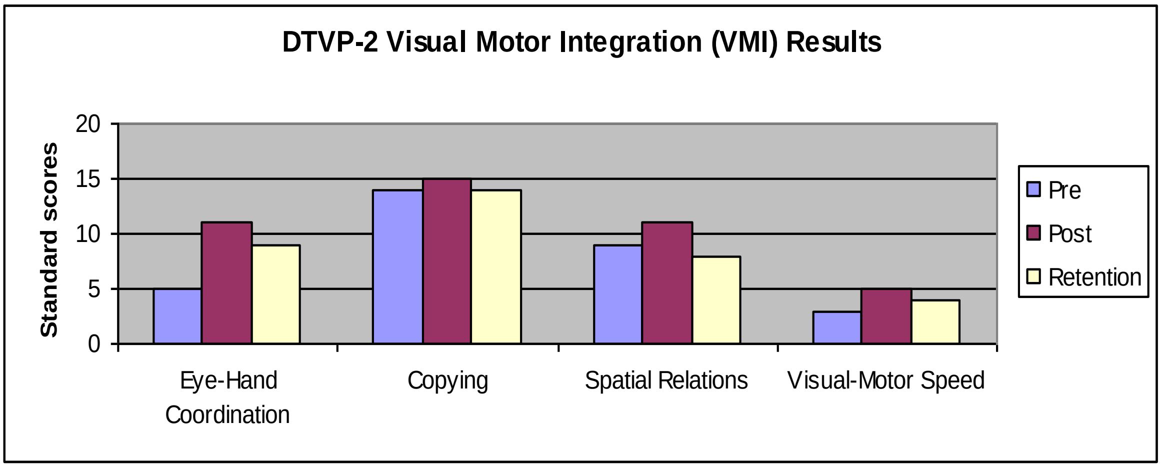

Figure 38. *DTVP-2 (VMI) pre-, post- and retention test standard scores.*

Standard Scores

Standard scores allow the results from the different tests to be compared to each other in order get an integrated picture of James's performance in terms of VMI. Table 11 presents the sums of the standard scores and then the conversion of the sums into composite scores. The interpretation of these values into a kind of rating scale is provided in Table 12 and allows a holistic assessment of James's progress in terms of visual-motor integration.

Table 11

DTVP-2 (VMI) Pre-, Post-, Retention test and Composite Scores

Subtests (VMI)	**Standard Scores**		
	Pre	Post	Retention
Eye-Hand Coordination	5	11	9
Copying	14	15	14
Spatial Relations	9	11	8
Visual-Motor Speed	3	5	4
Standard scores total	**31**	**42**	**35**
Percentile	**16**	**58**	**30**
Quotient	**85**	**103**	**92**

Table 12

DTVP-2 (VMI) rating scale for the interpretation of quotients and standard scores

Standard Scores	**Descriptive Rating**	**Quotients**
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

According to the standard scores that James earned on the individual test items, the following results can be noted:

- Eye-hand coordination improved from the poor category to the average category with his pre-test score of 5 climbing to 11 on the post-test and 9 on the retention test.

- Scores for copying were 14 on the pre-test, 15 on the post-test and 14 on the retention test, which kept his rating in the above average category although the post-test score of 15 technically fell into the superior category.

- Despite fluctuations in his scores on the spatial relations test from 9 to 11 to 8, James's ratings remained consistently in the average category.

- His scores for visual-motor speed improved from 3 on the pre-test to 5 on the post-test and then dropped to 4 on the retention test. These results shifted his rating from very poor to poor for visual-motor speed.

Percentile Scores

Percentile scores allow the comparison between James's performance and the performances of other children his age. Table 13 presents his scores on the VMI tests of the DTVP-2 converted to percentiles (his position relative to other children of his age).

- His eye-hand coordination performance improved from the 5th percentile on the pre-test to the 63rd percentile on the post-test, and dropped to the 37th percentile on the retention test.

- James's results for copying placed him in the 92nd percentile on the pre-test, 95th percentile on post-test and 91st percentile on the retention test. This was a very constant and high performance in relation to the other tests in the DTVP-2, as well as to children of the same age.

- James scores placed him in the 37th percentile for spatial relations and this rating improved to the 63rd percentile on the post-test. His retention test performance dropped his rating to the 25th percentile.

- The pattern of his scores for visual-motor speed showed the lowest scores of the four tests, lying at the 1st percentile on the pre-test. He only improved to the 5th percentile on post-test and dropped to the 2nd percentile on the retention test.

Table 13

The conversion of James's VMI (DTVP-2) standard scores to percentiles

Subtests (VMI)	**Pre-test Percentile**	**Post-test Percentile**	**Retention test Percentile**
Eye-hand coordination	5	63	37
Copying	92	95	91
Spatial relations	37	63	25
Visual-motor speed	1	5	2
Total Percentile Ranking	**16**	**58**	**30**

Composite Quotients

According to the DTVP-2 test manual (Hammill *et al.*, 1993) the composite quotient score is the most reliable result to use when interpreting results for a child in order to track changes in his/her integrated VMI performance (all four variables taken into account). The quotient scores for James are presented in Figure 39. James's pre-test quotient score was 85. It increased to 103 for the post-test and decreased to 92 on the retention test. James's performances improved from the below average category on pre-test to the average category on both the post-test and the retention test.

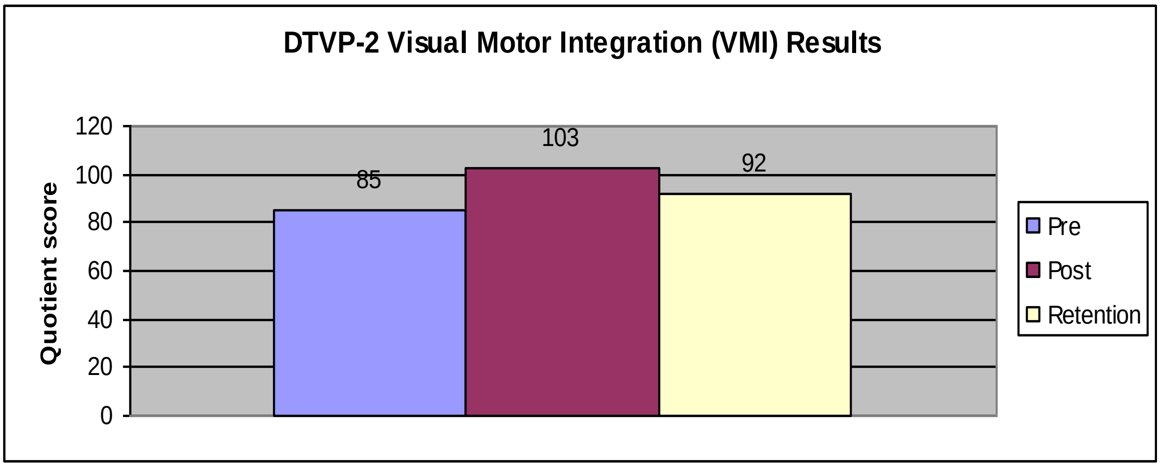

Figure 39. *VMI (DTVP-2) pre-, post- and retention test quotients.*

Research Question Three

6. How did the children feel about their participation in the small group-based intervention programme?

At a separate and individual interview session following the retention test, James answered several questions about how he experienced the intervention programme. He indicated he enjoyed the programme very much and would want to do it again.

Content of the Programme

James was asked what specifically he could recall about the activities in the programme, if he felt that he learned anything new, and if it was easier to do the activities toward the end of the programme. He remembered all the different games they played on the rebound nets. He said that he learned to throw and catch with one hand and thought that the activities definitely got easier for him at the end of the programme.

Structure of the Lessons

He was asked if he enjoyed the small group sessions or if he would have preferred individual sessions. He was also asked if he could remember the other children in his group. He said that he liked the small group but that he would prefer individual lessons in future because the group sessions made him feel “under pressure” and that the others pushed him too much. Although there were four in his group, he could only recall the names of Tom and Leigh.

Overall Evaluation of the Programme

In terms of his overall evaluation of the programme, James spontaneously said that he enjoyed everything. He said there was not anything that he did not enjoy and he would do the programme again anytime because he liked playing on the rebound nets. James claimed to have done all is homework with his mother assisting him.

Post-programme Comments about James

During the six-week programme James was one of the most consistent children with regards to his positive attitude and the progress he appeared to make in his skills. Every time he succeeded with something he was eager to try something more challenging. He always had a smile on his face and could keep himself busy practicing on those occasions when he either finished a task before the rest of his group and had to wait for the next instructions, or when he had to wait for his turn. He was always the first to arrive at class and the last to leave.

Case Study Four: Luke

Luke was a seven year old boy in Grade 1 and quite short compared to the other children in his class. He was right hand dominant although he was sometimes unsure about which hand he preferred to use for holding a pencil for write or when throwing a ball. It was not certain whether he had midline crossing problems or had not yet determined which his dominant hand was.

Luke may not have been ready for Grade 1 this year if one looks at all the different developmental aspects. Emotionally, socially, physically and cognitively he seemed to lag behind his peers of the same age. Physically, Luke showed signs of motor delays and clumsiness. He appeared to have poor balance even when simply walking from one place to another. Luke had a definite speech problem which made it very difficult to hear and to understand him when he spoke. He often still talks in a baby-like voice. Socially he did not appear to have adapted to the school setting, and he did not really interact with the other children in his group. He cried quite easily if frustrated or upset.

Luke appeared to have a very busy imagination and his attention tended to wander to “doing his own thing” while talking to himself. Luke gave the impression that he could literally “switch off” and forgets what he was supposed to do or what he was busy doing. Luke had a facilitator in class to help him with his academic work.

Research Question One

7. What were the effects of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?

The results of the fives tests of gross motor proficiency (both raw scores and standard scores) on the M-ABC were used to determine the impact of the programme on Luke. Changes were found in all his results (eye-hand coordination, dynamic balance and static balance). The conversion to standard M-ABC scores also indicated that he had coordination and balance difficulties in all these areas compared to other children of his age. Luke’ performance deteriorated, specifically on the bean bag throw (a test of aiming) and his static balance. It can be concluded that the programme had a positive influence on Luke's dynamic balance and his one-hand bounce and catch (coincident timing).

Results for Eye-hand Coordination (Ball Skills)

Two tests assessed eye-hand coordination and Luke showed very poor results on the first one – the beanbag throw that emphasised aiming. Luke scored highest on the pre-test with 8 out of 10 throws into the box. However, on the post-test he scored only 4 out of 10 and on the retention test he scored only 3 out of 10 throws into the box. This can be seen in Figure 40.

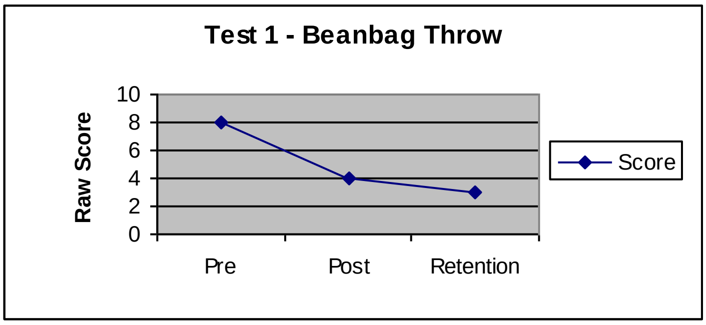

Figure 40. *Raw Scores on the beanbag throw (aiming).*

When Luke's raw scores were converted to standard scores (between 0 and 5), he achieved a 0 on the pre-test, but scores of 2 on the post-test and 3 on the retention test (see Figure 41). These results indicate that for his age, he is considered to have coordination problems in terms of eye-hand coordination (aiming).

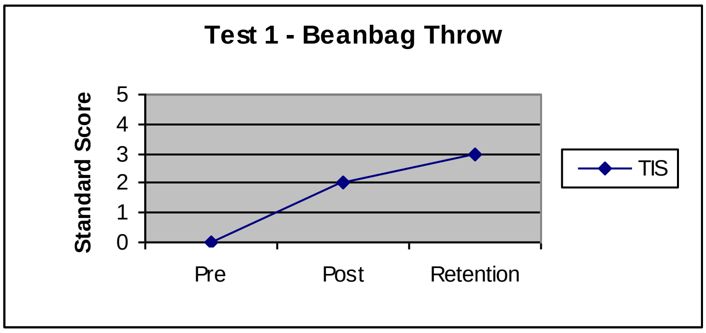

Figure 41. *M-ABC standard score on the beanbag throw (aiming).*

Luke showed inconsistent eye-hand coordination skills with his right hand in the one-hand bounce and catch test and overall poor control with his left hand. With the right hand he scored 10 out of 10 on the pre-test and again on the retention test, but his post-test performance was only 4 out of 10. With his left hand he scored 5 out of 10 on all three tests (see Figure 42).

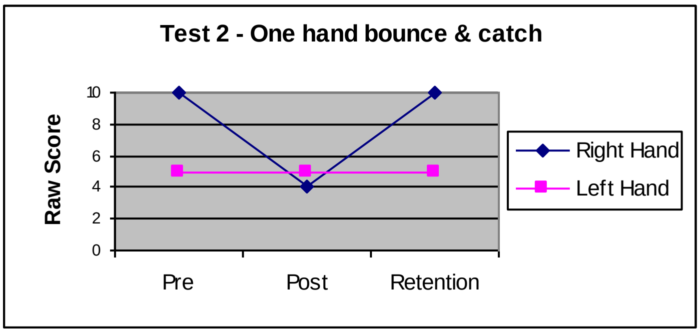

Figure 42. *Raw Scores on the bounce and catch test for right and left hand (coincident timing).*

Luke's raw scores were converted to standard scores of 1.5, on the pre-test, 3.5 on the post-test and back to 1.5 on the retention. This pattern indicates that he is highly variable in his performance. He sometimes appears to have coordination problems compared to other children his age, but at other times appears to be similar to his peers (see Figure 43). Inconsistency can be a sign of coordination problems.

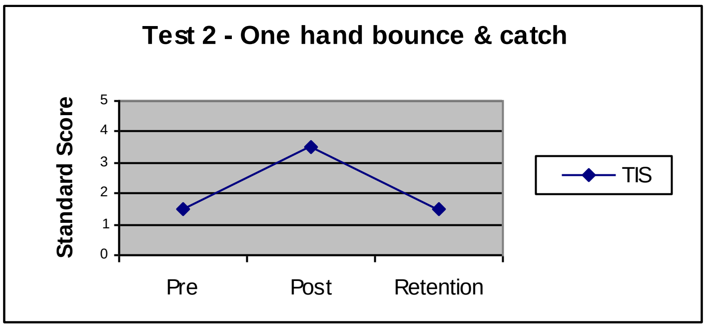

Figure 43. *M-ABC standard scores on the bounce and catch test for right and left hand (coincident timing).*

Dynamic Balance

Looking at the standard scores Luke did well on both the dynamic balance tests. After a pre-test score of 4 out of 5, he was able to complete 5 out of 5 jumps in the squares of the ladder on the post-test and again on the retention test (see Figure 44).

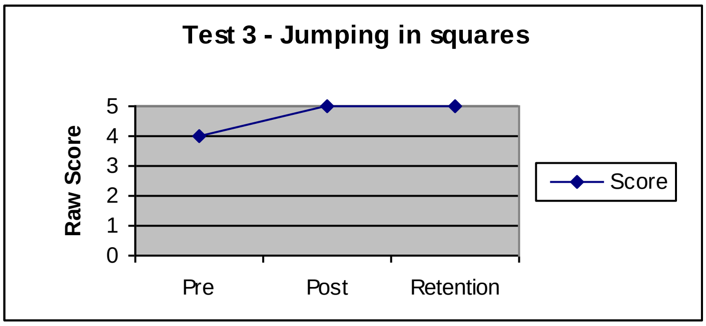

Figure 44. *Raw Scores on the jumping in squares test (dynamic balance).*

Luke's raw score converted to a standard score of 2 on the pre-test and 0 on both the post-test and the retention test. This indicated that he had no coordination difficulties with this measure of dynamic balance for someone in his age group (see Figure 45).

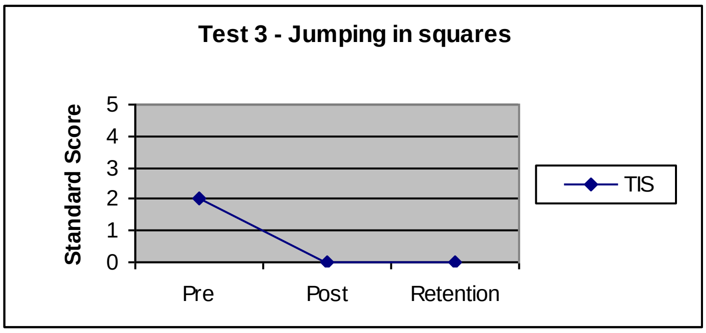

Figure 45. *M-ABC standard scores on the jumping in squares test (dynamic balance).*

On the heel-toe walking test, Luke once again showed inconsistent results. He earned raw scores of 12 on the pre-test, 15 on the post-test and 8 on the retention test (see Figure 46). In other words, his lowest score was on the retention test.

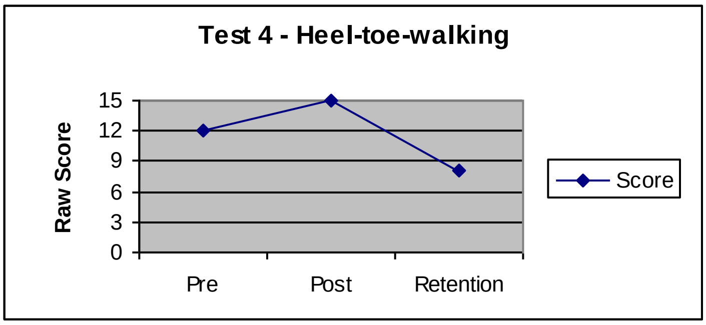

Figure 46. *Raw Scores on the heel-toe walking test (dynamic balance).*

When converted to a standard score, Luke earned a 1 on the pre-test, 0 on the post-test and 1 on the retention test, indicating that these test results did not establish that Luke had any dynamic balance problems compared to other children his age.

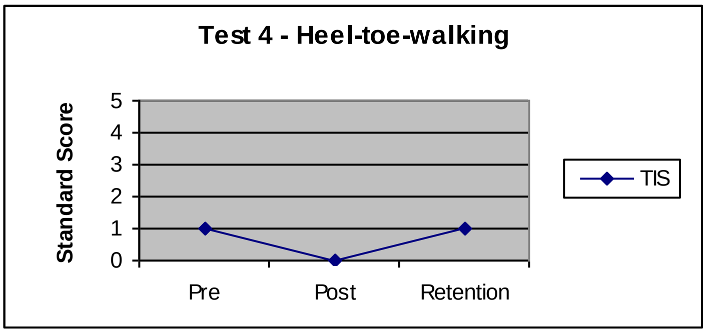

Figure 47. *M-ABC standard scores on the heel-toe walking test (dynamic balance).*

Static Balance

In the test of static balance, Luke showed inconsistent results for both his left and right legs from the pre-test to retention test (see Figure 48). Balance on his right leg was at the maximum score of 20 seconds on both the pre-test and the post-test, but dropped to 3 seconds on the retention test. On his left leg, he could only balance for 2 seconds on the pre-test, 8 seconds on the post-test and 2 seconds on the retention test.

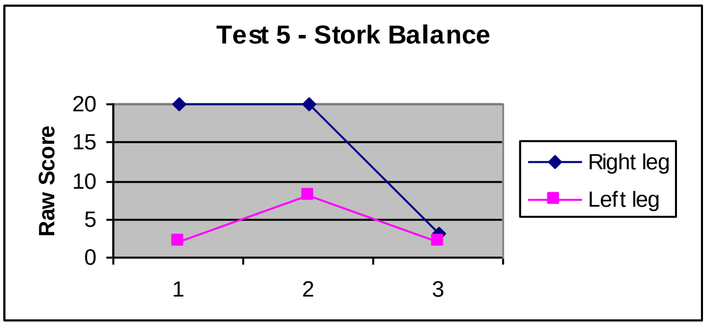

Figure 48. *Raw Scores on the stork balance test (static balance).*

As shown in Figure 49, Luke's raw scores converted to standard scores of 2.5 on the pre-test, 0.5 on the post-test and 5 on the retention test. The variation in these scores indicated that he had problems with his static balance when compared to other children his age.

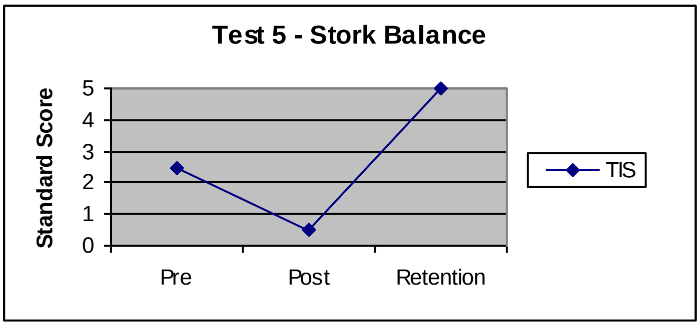

Figure 49. *M-ABC standard scores on the stork balance test (static balance).*

Research Question Two

8. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual motor integration abilities of children who show signs of DCD?

The results of the four tests of visual perception that assess visual motor integration from the DTVP-2 were used to determine the impact of the programme on Luke. He showed improvements only his eye-hand coordination and copying, with deterioration of his scores of spatial relations and visual-motor speed after participation in the intervention programme. When the quotient score that integrates the results of all four tests is considered, Luke's VMI was rated in the poor category on the pre-tests, post-tests and retention tests. This suggests that although there were improvements in eye-hand coordination and copying, the intervention programme did not have a sufficiently positive effect on his overall VMI to change his rating compared to other children his age. The standard scores for Luke's performance on each of the four variables (pre-test, post-test and retention test) are presented in Figure 50.

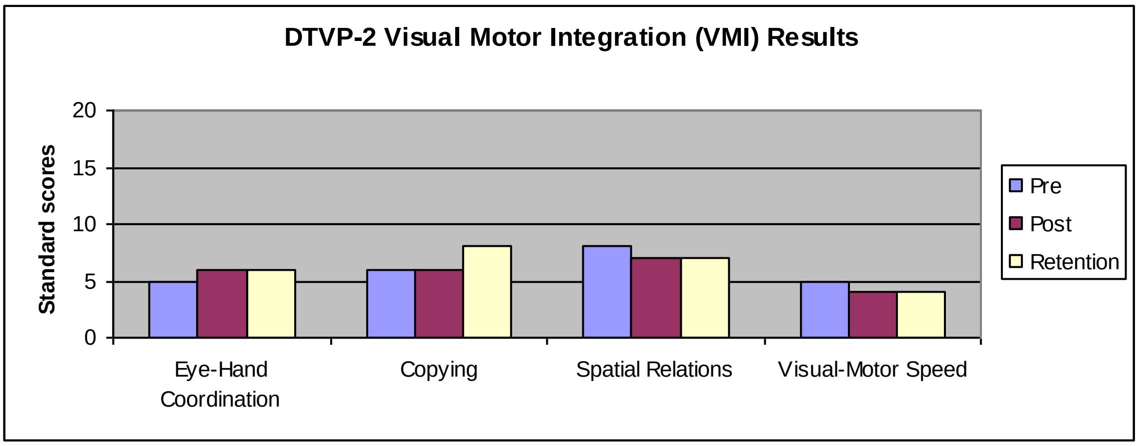

Figure 50. *DTVP-2 (VMI) pre-, post- and retention test standard scores.*

Standard Scores

Standard scores allow the results from the different tests to be compared to each other in order get an integrated picture of Luke's performance in terms of VMI. Table 14 presents the sums of the standard scores and then the conversion of the sums into composite scores. The interpretation of these values into a kind of rating scale is provided in Table 15 and allows a holistic assessment of Luke's progress in terms of visual-motor integration.

Table 14

DTVP-2 (VMI) Pre-, Post-, Retention-test and Composite Scores

Subtests (VMI)	**Standard Scores**		
	Pre	Post	Retention
Eye-Hand Coordination	5	6	6
Copying	6	6	8
Spatial Relations	8	7	7
Visual-Motor Speed	5	4	4
Standard scores total	**24**	**23**	**26**
Percentile	**3**	**3**	**6**
Quotient	**73**	**72**	**77**

Table 15

DTVP-2 (VMI) rating scale for the interpretation of quotients and percentiles

Standard Scores	**Descriptive Rating**	**Quotients**
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

According to the standard scores that Luke earned on the individual test items, the following results can be noted:

- Eye-hand coordination improved from the poor category to the below average category with his pre-test score of 5 climbing to 6.

- Scores for copying were 6 on the pre- and the post-test and 8 on the retention test, improving his rating from the below average to the average category.

- The decrease in his score on spatial relations from 8 to 7 dropped Luke's ratings in this category from the average group to below average.

- His scores for visual-motor speed decreased from 5 on the pre-test to 4 on the post-test and on the retention test. These results kept his rating in the poor category.

Percentile Scores

Percentile scores allow the comparison between Luke's performance and the performances of other children his age. Table 16 presents his scores on the VMI tests of the DTVP-2 converted to percentiles (his position relative to other children of his age).

- His eye-hand coordination performance improved from the 5th percentile on the pre-test to the 9th percentile on the post-test, an improvement that was maintained on the retention test.

- Luke's results for copying placed him in the 9th percentile on both the pre-test and post-test, with an increase to the 25th percentile on the retention test.

- There was a change in his percentile score for spatial relations. His pre-test performance put him in the 25th percentile but he was not able to record a higher score on either the post-test or the retention test which converted only to the 16th percentile.

- The pattern of his scores for visual-motor speed showed the lowest scores of the four tests on both the post-test and retention test (2nd percentile). His score on the pre-test was not much higher and converted to the 5th percentile.

Table 16

The conversion of Luke's VMI (DTVP-2) standard scores to percentiles

Subtests (VMI)	Pre-test Percentile	Post-test Percentile	Retention test Percentile
Eye-hand coordination	5	9	9
Copying	9	9	25
Spatial relations	25	16	16
Visual-motor speed	5	2	2
Total Percentile Ranking	**3**	**3**	**6**

Composite Quotients

According to the DTVP-2 test manual (Hammill *et al.,* 1993) the composite quotient score is the most reliable result to use when interpreting results for a child in order to track changes in his/her integrated VMI performance (all four variables taken into account). The quotient scores for Luke are presented in Figure 51. Luke's pre-test quotient score was 73. It decreased to 72 on the post-test and then went up to 77 on the retention test. Despite the apparent changes, Luke's performances were in the poor category on each test occasion.

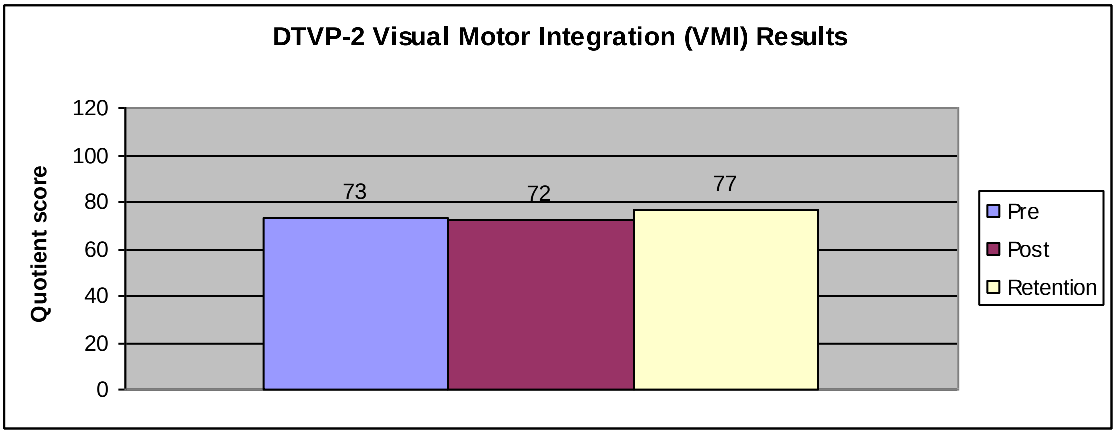

Figure 51. *VMI (DTVP-2) pre-, post- and retention test quotients.*

Research Question Three

9. How did the children feel about their participation in the small group-based intervention programme?

At a separate and individual interview session following the retention test, Luke answered several questions about how he experienced the intervention programme. He indicated he enjoyed the programme and would like to do it again.

Content of the Programme

Luke was asked what specifically he could recall about the activities in the programme, if he felt that he learned anything new, and if it was easier to do the activities toward the end of the programme. He mentioned that he could remember the games on the rebound nets and also jumping through the ladder. He said the activities definitely became easier towards the end of the programme, specifically throwing and catching and balancing on one leg. He also said he learned to jump better and how to bounce and catch the ball with one hand.

Structure of the Lessons

He was asked if he enjoyed the small group sessions or if he would have preferred individual sessions. He was also asked if he could remember the other children in his group. He said that he did not enjoy working in small groups of four and would have preferred individual lessons. He gave as his reason that the other children always “fight” with him. He thought one reason they did this was because he was so much slower than they were so they got upset with him. He was in the group of three and recalled that Peter and Daniel were in his group.

Overall Evaluation of the Programme

In terms of his overall evaluation of the programme, Luke said that he enjoyed throwing balls at the rebound nets the most because it was a lot of fun. He reported that hopping on one leg seemed to have hurt him and therefore he did not enjoy it. He said he would do the programme again because it was a lot of fun. Luke claimed that his mother helped him with his homework every week.

Post-programme Comments about Luke

After observing Luke throughout the six-week programme and taking his results in consideration, it becomes clear to the investigator that some of his coordination problems were linked to his difficulties controlling his attention and sustaining effort. He did not make satisfactory progress in his gross motor skills during the six weeks and did not seem to have benefited much from the participation in the programme.

His scores on the DTVP2 were also quite low which suggests he may have a visual-motor integration problem. For example, when he needed to track a ball in order to catch it, it seemed as if he missed tracking the ball entirely and only saw the ball once he had missed it. Luke did seem to enjoy the programme although he failed to successfully perform most of the activities in most of the training sessions.

Case Study Five: Tom

Tom was an eight year old boy and in Grade 2. He was right hand dominant and of average height and weight for his age. His physical education teacher reported that she had only noticed his motor coordination problems and was not aware of any co-morbid signs such as those related with attention problems, etc.

Tom participated in cricket and seemed to enjoy physical activity in general. Emotionally he appeared to be mature, never doing anything to seek attention. He did not appear to frustration at his lack of motor proficiency. If he did experience negative emotions, he was able to manage them within himself. The coordination of his motor performance was the only developmental area in which he was not above average compared to other children his age.

Research Question One

10. What were the effects of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?

The results of the fives tests of gross motor proficiency (both raw scores and standard scores) on the M-ABC were used to determine the impact of the programme on Tom. No changes were found in either his eye-hand coordination (coincident timing) or his dynamic balance as a result of participation in this programme. The conversion to standard M-ABC scores also indicated that he had no coordination difficulties in these areas

Tom's static balance on his left leg was at the maximum level on all three test occasions. Static balance on his right leg showed some problems on the pre-test, but improved by the post-test to a maximum level, which was sustained on the retention test. There was room for improvement of his raw scores on the test of eye-hand coordination (aiming). His performance was actually weaker on the post-test and the retention test than it was on the pre-test. It can be concluded that the programme had a positive influence on Tom's static balance, but that his eye-hand coordination (aiming for accuracy) still needs improvement.

Results for Eye-hand Coordination (Ball Skills)

Two tests assessed eye-hand coordination and Tom showed mixed results. On the pre-test of the beanbag throw for accuracy, Tom got 8 out of the 10 throws in the box, but unfortunately dropped to 5 out of 10 throws on the post-test and the retention test. This can be seen in Figure 52.

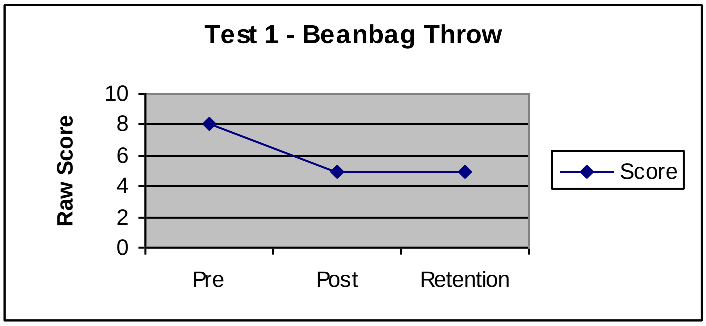

Figure 52. *Raw Scores on the beanbag throw (aiming).*

When Tom’s raw scores were converted to standard scores (between 0 and 5), he achieved a 0 for the pre-test opportunity and dropped to a score of 1 on the post-test and retention test (see Figure 53). These results indicate that for his age, he is considered to have a slight coordination problem on this test of eye-hand coordination (aiming).

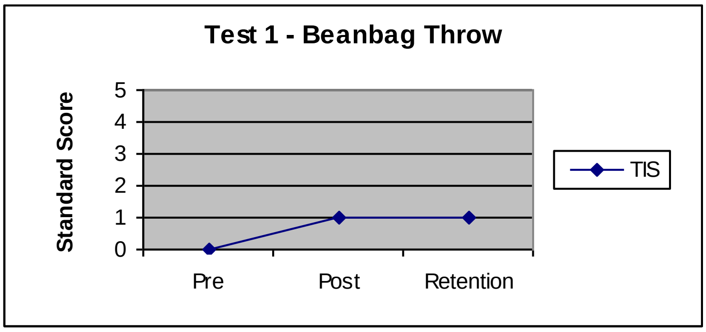

Figure 53. *M-ABC standard score on the beanbag throw (aiming).*

Tom showed good eye-hand coordination skills in the one-hand bounce and catch test. He scored 8 out of 10 with the right hand and 10 out of 10 with the left hand on the pre-test. He caught all 10 balls with his right hand on the post-test and retention test (see Figure 54). With his left hand he scored 9 out of 10 on both the post-test and the retention test. This was a good and consistent performance with both his non-preferred and preferred hand.

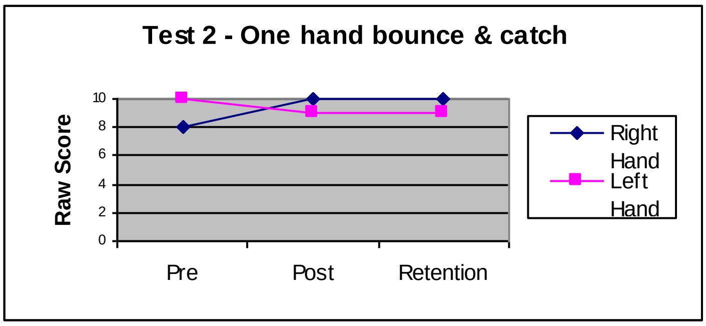

Figure 54. *Raw Scores on the bounce and catch test for right and left hand (coincident timing).*

Achieving high marks on all three test occasions for both hands converted to standard scores of 0, indicating that Tom had no coordination problems in this area for a child his age (see Figure 55).

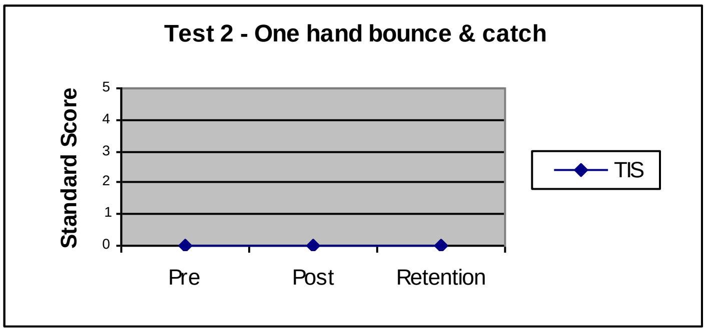

Figure 55. *M-ABC standard scores on the bounce and catch test for right and left hand (coincident timing).*

Dynamic Balance

Tom did well on both tests of dynamic balance. He completed 5 out of 5 jumps in the squares of the ladder on all three test occasions (see Figure 56).

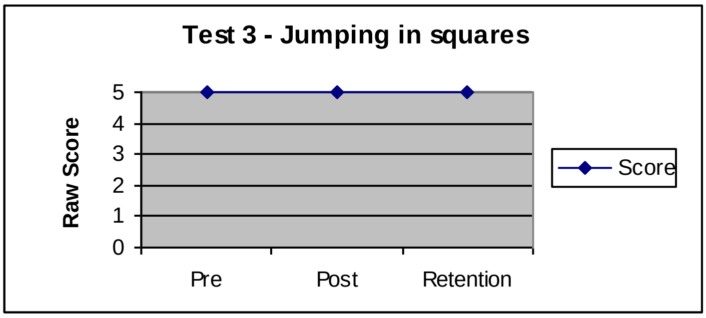

Figure 56. *Raw Scores on the jumping in squares test (dynamic balance).*

Tom’s raw scores converted to a standard score of 0 which indicated he had no coordination difficulties with this measure of dynamic balance for a child his age (see Figure 57).

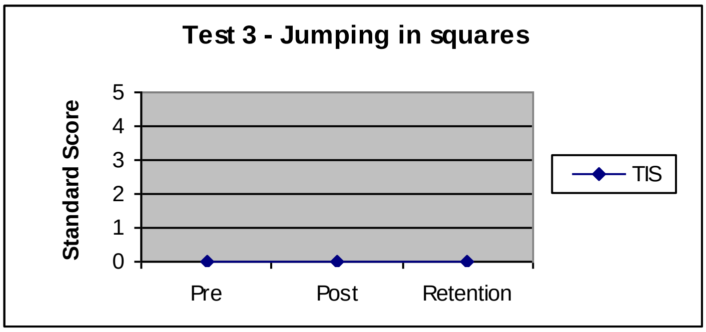

Figure 57. *M-ABC standard scores on the jumping in squares test (dynamic balance).*

On the heel-toe-walking test, Tom once again showed good dynamic balance. He earned raw scores of 15 on all three test occasions with zero errors (see Figure 58).

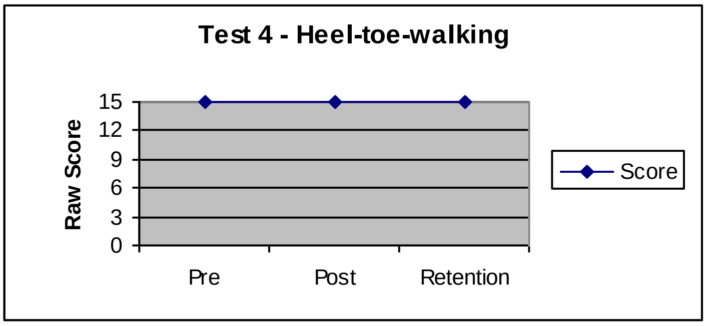

Figure 58. *Raw Scores on the heel-toe walking test (dynamic balance).*

When converted to a standard score, Tom earned 0 on all three test occasions, indicating no dynamic balance problems for a child his age.

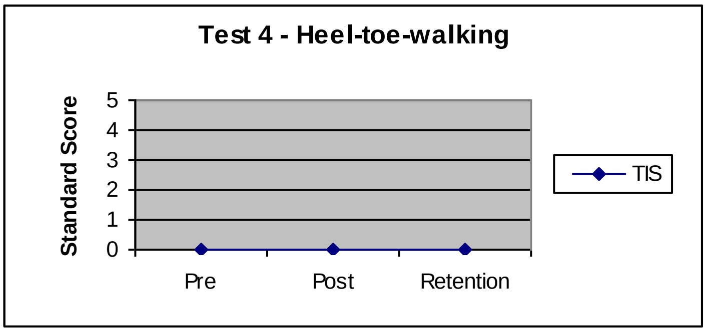

Figure 59. *M-ABC standard scores on the heel-toe walking test (dynamic balance).*

Static Balance

In the test of static balance, Tom showed a substantial improvement for his right leg from the pre- to post-test, and he was able to sustain this improvement on the retention test (see Figure 60). He improved from 8 seconds to 20 seconds. The static balance on his left leg was well coordinated from the beginning of the programme. He scored the 20 second maximum on all three test occasions.

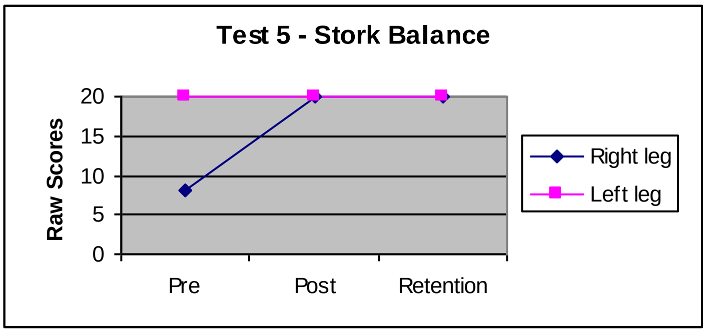

Figure 60. *Raw Scores on the stork balance test (static balance).*

As shown in Figure 61, Tom's pre-test standard score of 1.5 indicated that he has some mild problems with his static balance on his right leg. However, his improvements converted to standard scores of 0 on both the post-test and the retention test. This took him to the category of no problems with static balance for a child of his age, following his participation in the intervention programme.

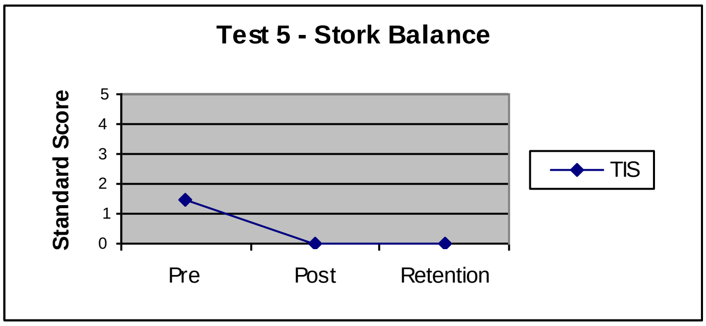

Figure 61. *M-ABC standard scores on the stork balance test (static balance).*

Research Question Two

11. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual motor integration abilities of children who show signs of DCD?

The results of the four tests of visual perception that assess visual motor integration from the DTVP-2 were used to determine the impact of the programme on Tom. He showed no changes in his eye-hand coordination and those scores were quite low. His copying abilities stayed the same from pre-test to post-test, with a slight improvement on the retention test. There was an improvement in his visual motor speed after participation in the intervention programme, although the improvement was dramatically reversed to become his lowest score on the retention test of visual-motor speed. His spatial relations score deteriorated from pre-test to post-test, but recovered on the retention. When the quotient score that integrates the results of all four tests is considered, Tom's VMI was rated as average on the pre-test and below average on the post- and retention tests. This pattern of results suggests the intervention programme did not have an effect on his overall VMI. The standard scores for Tom's performance on each of the four variables (pre-test, post-test and retention test) are presented in Figure 62.

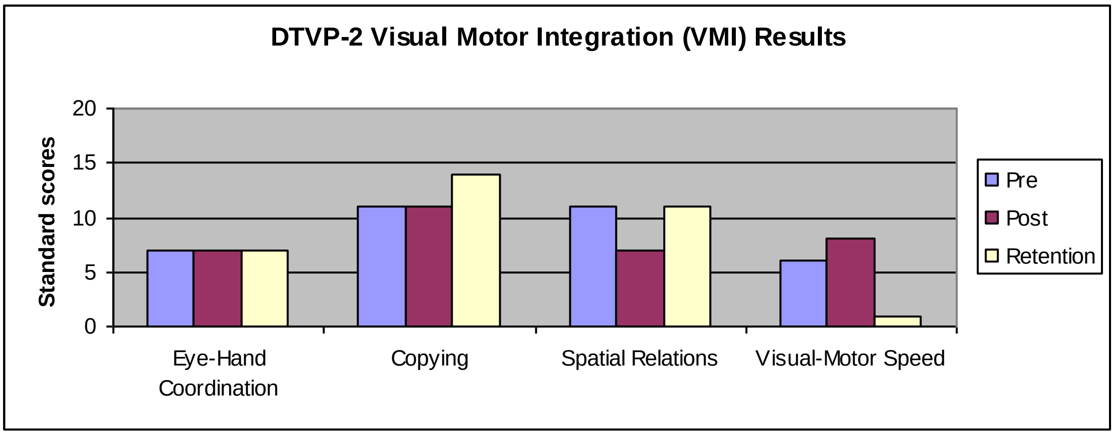

Figure 62. *DTVP-2 (VMI) pre-, post- and retention test standard scores.*

Standard Scores

Standard scores allow the results from the different tests to be compared to each other in order get an integrated picture of Tom's performance in terms of VMI. Table 17 presents the sums of the standard scores, and then the conversion of the sums into composite scores. The interpretation of these values into a kind of rating scale is provided in Table 18 and allows a holistic assessment of Tom's progress in terms of visual-motor integration.

Table 17

DTVP-2 (VMI) Pre-, Post-, Retention test and Composite Scores

Subtests (VMI)	**Standard Scores**		
	Pre	Post	Retention
Eye-Hand Coordination	7	7	7
Copying	11	11	14
Spatial Relations	11	7	11
Visual-Motor Speed	6	8	1
Standard scores total	**35**	**33**	**33**
Percentile	**30**	**21**	**21**
Quotient	**92**	**88**	**88**

Table 18

DTVP-2 (VMI) rating scale for the interpretation of quotients and percentiles

Standard Scores	**Descriptive Rating**	**Quotients**
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

According to the standard scores that Tom earned on the individual test items, the following results can be noted:

- Eye-hand coordination showed no change and stayed in the below average category throughout all three test occasions with a score of 7.
- Scores for copying were 11 on the pre- and the post-test and 14 at retention-testing, shifting his rating from the average to above average category.
- The decrease in his score on spatial relations from 11 to 7 dropped Tom's ratings in this category from the average group to below average. His score of 11 again on the retention test placed his score back in the average group for this test.
- His scores for visual-motor speed varied a lot. First it improved from 6 on the pre-test to 8 on the post-test and then it dropped to 1 on the retention test. These results shifted his rating from average to very poor for visual-motor speed.

Percentile Scores

Percentile scores allow the comparison between Tom's performance and the performances of other children his age. Table 19 presents his scores on the VMI tests of the DTVP-2 converted to percentiles (his position relative to other children of his age).

- His eye-hand coordination performance stayed consistent and in the 16th percentile throughout all three test occasions.
- Tom's results for copying started on the 63rd percentile in both the pre- and post-test. He improved to the 91st percentile on the retention test.
- His pre-test performance for spatial relations put him in the 63rd percentile, while his post-test showed a drop to the 16th percentile. His retention test performed place him back in the 63rd percentile.

- The pattern of his scores for visual-motor speed placed him in the 9th percentile on pre-test, which improved to 25th percentile on post-test. His score on the retention test was converted to 0 percentile.

Table 19

The conversion of Mark's VMI (DTVP-2) standard scores to percentiles

Subtests (VMI)	**Pre-test Percentile**	**Post-test Percentile**	**Retention test Percentile**
Eye-hand coordination	16	16	16
Copying	63	63	91
Spatial relations	63	16	63
Visual-motor speed	9	25	0
Total Percentile Ranking	**30**	**21**	**21**

Composite Quotients

According to the DTVP-2 test manual (Hammill *et al.,* 1993) the composite quotient score is the most reliable result to use when interpreting results and tracking changes in integrated VMI performance. Tom's pre-test quotient score was the highest on 92. It decreased to 88 on the post-test and remained at 88 on the retention test. This change in Tom's performances shifted his overall VMI rating from the average to below average category (see Figure 63).

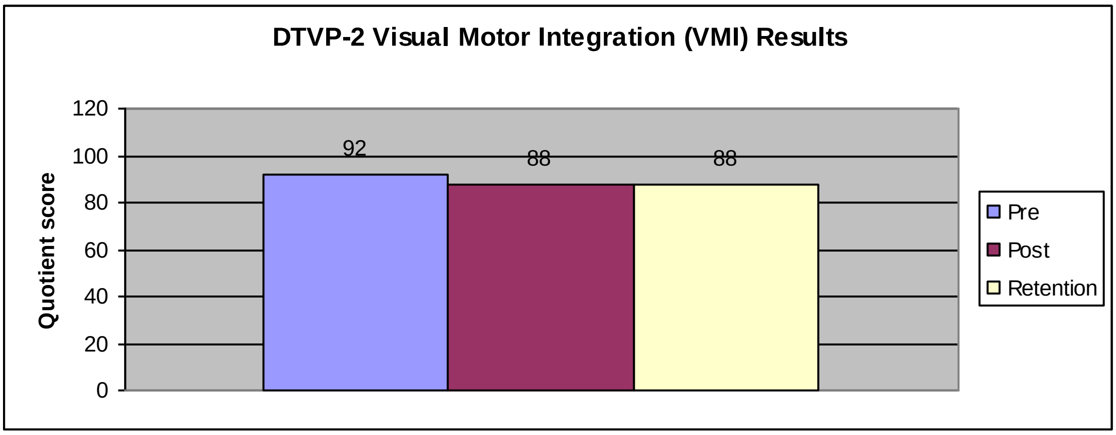

Figure 63. *VMI (DTVP-2) pre-, post- and retention test quotients.*

Research Question Three

12. How did the children feel about their participation in the small group-based intervention programme?

At a separate and individual interview session following the retention test, Tom answered several questions about how he experienced the intervention programme. He indicated he enjoyed the programme very much that he would love to do it again.

Content of the Programme

Tom was asked what specifically he could recall about the activities in the programme, if he felt that he learned anything new, and if it was easier to do the activities toward the end of the programme. Tom remembered activities that involved rebound nets and ladders, and that he had to throw, catch, skip, hop and bounce. He felt that the exercises got easier towards the end of the programme and noticed that some of the activities were repeated each week. He did not feel that he really learned something completely new.

Structure of the Lessons

He was asked if he enjoyed the small group sessions or if he would have preferred individual sessions. He was also asked if he could remember the other children in his group. He loved the group sessions and said that playing with the other children made the lessons fun so he would prefer working in groups again. He remembered that Mark, Lisa and James were part of his group.

Overall Evaluation of the Programme

In terms of his overall evaluation of the programme, Tom said that he enjoyed everything and that the activities with the ladders were the most fun. He claimed to have done his homework all by himself, and he would do the programme again anytime because it was fun. He also told his family each week about what he did in the lesson that day.

Post-programme Comments about Tom

Tom was very consistent throughout the programme regarding his scores, performances and attitude. He did not show any signs of a concentration or attention span problems. Tom could always keep himself busy and did not distract anyone around him. Any challenges he may have with his motor coordination do not appear to have an influence on either his schoolwork or social interaction with his peers.

Case Study Six: Peter

Peter is seven years old, in Grade 1 and right hand dominant. He is quite tall compared to other children in his class. His physical education teacher identified him as a child who had some gross motor coordination problems and also mentioned that he sometimes had difficulty maintaining his concentration.

Peter was enthusiastic about playing hockey and appeared to be happy when he was around his friends. He seemed to be very sociable and did not seem to do anything on his own. His teacher reported that he would try to find a way out of doing anything that did not interest him. She described him as a child who would either stand and do nothing or start doing something with his peers, when confronted with a task he did not want to do.

Research Question One

13. What is the effect of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?

The results of the fives tests of gross motor proficiency (both raw scores and standard scores) on the M-ABC were used to determine the impact of the programme on Peter. No improvements were achieved in either his eye-hand coordination or his dynamic balance, but these were areas in which his raw scores were quite high or maximum for the test item. The conversion to standard M-ABC scores also indicated that he had no coordination difficulties in these areas, although there was room for improvement of his raw scores on the test of aiming. However, both the raw scores and the standard scores for static balance showed a very good improvement which was sustained on the retention test. It can be concluded that the programme had a positive influence on Peter’s eye-hand coordination (both aiming and coincident timing) and made a contribution to the improvement of his static balance.

Results for Eye-hand Coordination (Ball Skills)

Two tests assessed eye-hand coordination and Peter showed good improvement in the first one. At pre-testing of the beanbag throw Peter got only 5 out of the 10 throws into the box, but that improved to 6 throws on the post-test and 7 on the retention test. This can be seen in Figure 64.

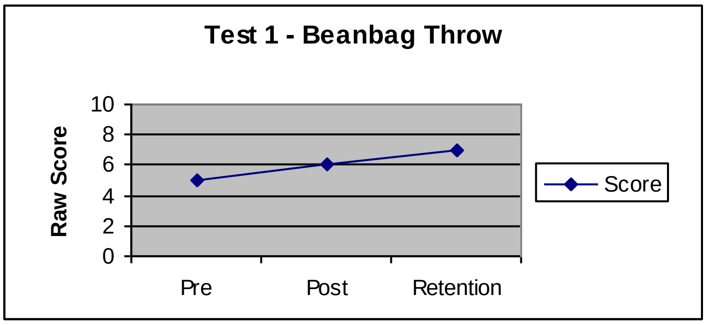

Figure 64. *Raw Scores on the beanbag throw (aiming).*

When Peter’s raw scores were converted to standard scores (between 0 and 5), he achieved a 1 for the first test opportunity but improved to 0 on the last two occasions (see Figure 65). The standard scores indicated that for his age, he was not considered to have coordination problems on this test of eye-hand coordination (aiming), although his raw scores showed room for improvement.

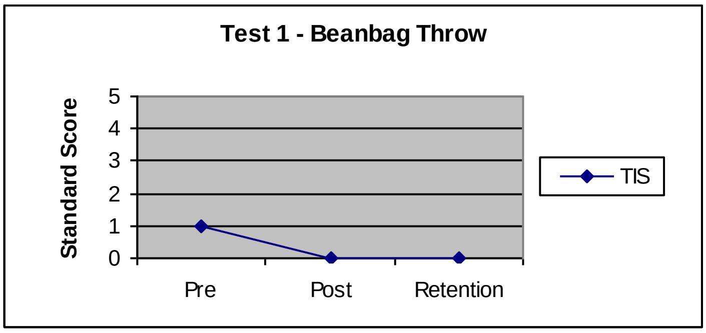

Figure 65. *M-ABC standard score on the beanbag throw (aiming).*

Peter achieved substantial improvements in his eye-hand coordination skills (coincident timing) in the one-hand bounce and catch test (see Figure 66). With his right hand he started very low with a score of 2 and improved to earn a full score of 10 on the post-test. This was followed with a slight drop to 9 on the retention test. The left hand showed great improvement by increasing from 6 on pre-test to 8 on post-test and 10 on retention test.

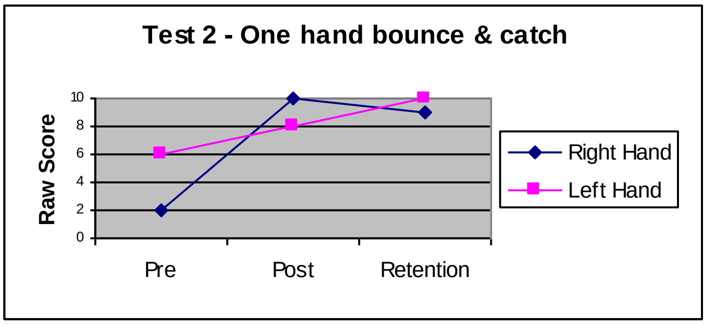

Figure 66. *Raw Scores on the bounce and catch test for right and left hand (coincident timing).*

After converting raw scores to standard scores, Peter's pre-test score was 3.5. He achieved high marks on the last two test occasions, converting to standard scores of 0, indicating that Peter had no coordination problems in this area when compared to other children his age (see Figure 67).

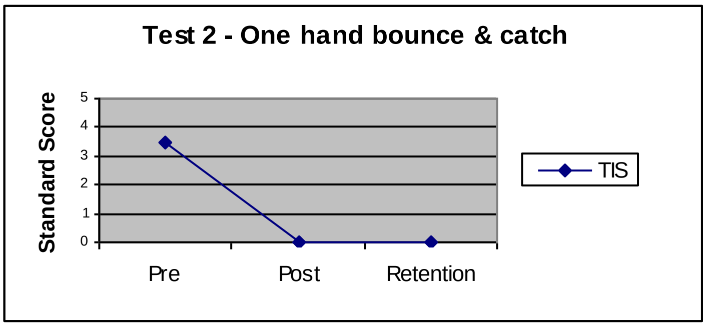

Figure 67. *M-ABC standard scores on the bounce and catch test for right and left hand (coincident timing).*

Dynamic Balance

Peter did well in both the dynamic balance tests. He completed 5 out of 5 jumps in the squares of the ladder on all three test occasions (see Figure 68).

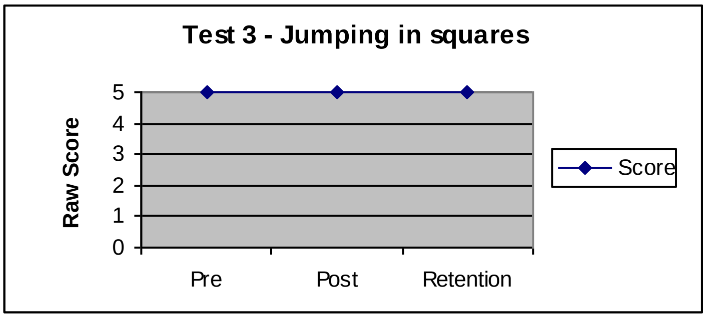

Figure 68. *Raw Scores on the jumping in squares test (dynamic balance).*

Peter's raw score converted to a standard score of 0 which indicated he had no coordination difficulties with this measure of dynamic balance for someone his age (see Figure 69).

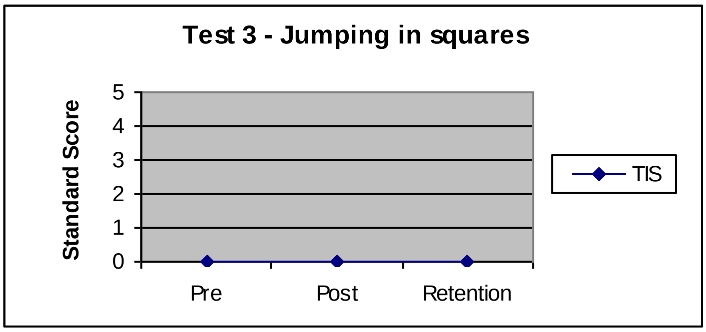

Figure 69. *M-ABC standard scores on the jumping in squares test (dynamic balance).*

On the heel-toe walking test, Peter did not show the same good dynamic balance skills as in jumping through the ladder. He earned raw scores of 10 on the pre-test, 8 on post-test and 12 on the retention test, with errors on all three tests (see Figure 70).

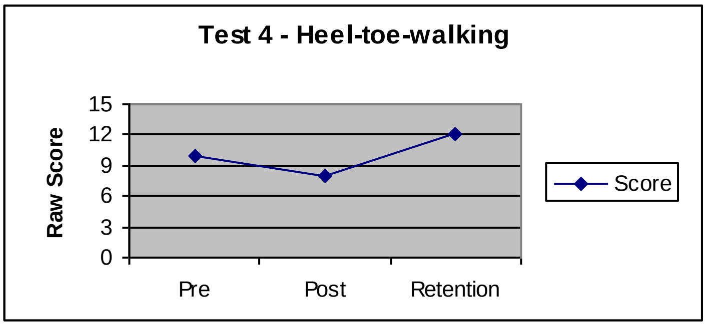

Figure 70. *Raw Scores on the heel-toe walking test (dynamic balance).*

When converted to a standard score, Peter earned a one on all three test occasions, indicating slight dynamic balance problems when compared to other children his age.

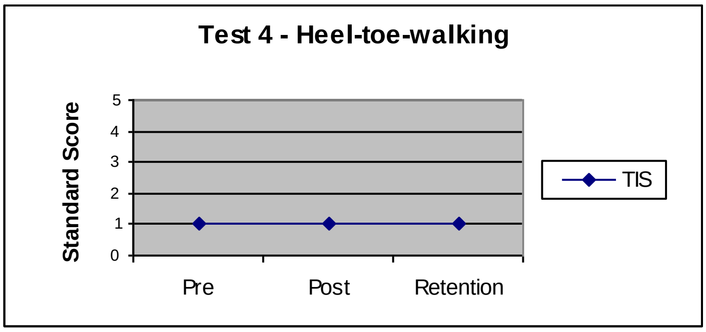

Figure 71. *M-ABC standard scores on the heel-toe walking test (dynamic balance).*

Static Balance

In the test of static balance, Peter showed a slight improvement for his left leg, but the same can not be said about his right leg (see Figure 72). His balance on his left leg improved from 3 seconds on the pre-test to 4 seconds on the post-test to 8 seconds on the retention test. For his right leg, he started on 8 seconds on the pre-test and dropped to 4 seconds on the post-test and 3 seconds on the retention test. This task involving standing on only one leg appeared to have presented him with coordination problems.

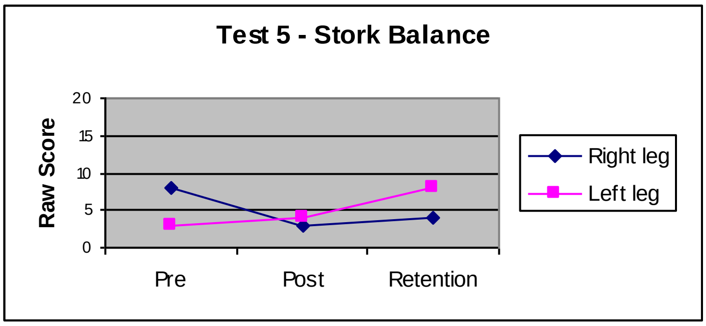

Figure 72. *Raw Scores on the stork balance test (static balance).*

As shown in Figure 73, Peter's pre-test standard score of 3 indicated that he has some moderate problems with his static balance. However, his improvements converted to standard scores of 2 and 2.5 on both the post-test and retention test. This took him to the category of definite problems with static balance for a child of his age.

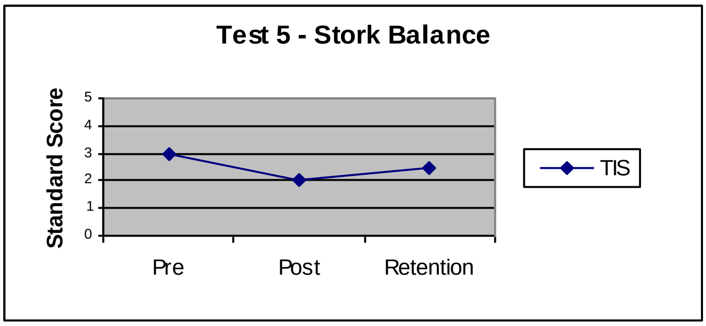

Figure 73. *M-ABC standard scores on the stork balance test (static balance).*

Research Question Two

14. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual motor integration abilities of children who show signs of DCD?

The results of the four tests of visual perception that assess visual motor integration from the DTVP-2 were used to determine the impact of the programme on Peter. He showed a slight improvement in his visual-motor speed after participation in the intervention programme. There was no change in his copying scores. It was in eye-hand coordination and spatial relations that his test performance deteriorated. When the quotient score that integrates the results of all four tests is considered, Peter's VMI was rated as poor on the pre-test, post-test and retention test. This suggests that although there were a very slight improvement in visual-motor speed, the intervention programme did not have an effect on any of the four skills individually or and on his overall VMI. The standard scores for Peter's performance on each of the four variables (pre-test, post-test and retention test) are presented in Figure 74.

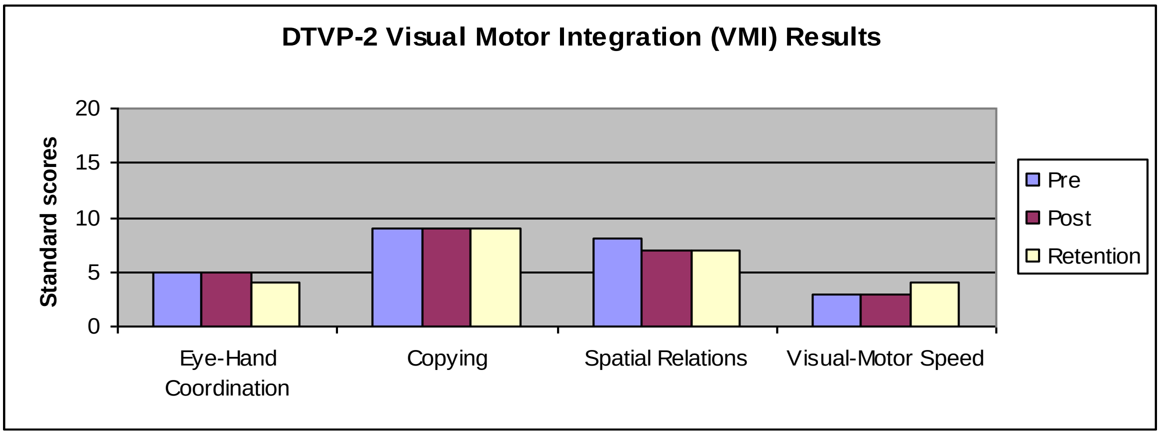

Figure 74. *DTVP-2 (VMI) pre-, post- and retention test standard scores.*

Standard Scores

Standard scores allow the results from the different tests to be compared to each other in order get an integrated picture of Peter's performance in terms of

VMI. Table 20 presents the sums of the standard scores, and then the conversion of the sums into composite scores. The interpretation of these values into a kind of rating scale is provided in Table 21 and allows a holistic assessment of Peter's progress in terms of visual-motor integration.

Table 20

DTVP-2 (VMI) Pre-, Post-, Retention test and Composite Scores

Subtests (VMI)	**Standard Scores**		
	Pre	Post	Retention
Eye-Hand Coordination	5	5	4
Copying	9	9	9
Spatial Relations	8	7	7
Visual-Motor Speed	3	3	4
Standard scores total	**25**	**24**	**24**
Percentile	**5**	**3**	**3**
Quotient	**75**	**73**	**73**

Table 21

DTVP-2 (VMI) rating scale for the interpretation of quotients and percentiles

Standard Scores	**Descriptive Rating**	**Quotients**
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

According to the standard scores that Peter earned on the individual test items, the following results can be noted:

- Eye-hand coordination was categorised as being poor in all three test-occasions, with the pre-test score of 5 dropping to 4 in the other two tests.
- Scores for copying were sustained at the score of 9 throughout all the tests, which is in the average category.
- The decrease in his scores on spatial relations from 8 to 7 also dropped Peter's ratings in this category from the average to below average.
- His scores for visual-motor speed improved from 3 on the pre- and post-test to 4 on the retention test. These results shifted his rating from very poor to poor for visual-motor speed.

Percentile Scores

Percentile scores allow the comparison between Peter's performance and the performances of other children his age. Table 22 presents his scores on the VMI tests of the DTVP-2 converted to percentiles (his position relative to other children of his age).

- His eye-hand coordination performance decreased from the 5th percentile on both the pre- and post-test to only the 2nd percentile on the retention test.
- Mark's results for copying placed him in the 37th percentile on all three test occasions.
- His pre-test performance on the test of spatial relations put him in the 25th percentile. However, his identical performances on post-test and the retention test only converted to the 16th percentile.
- The pattern of his scores for visual-motor speed also showed the lowest score possible on both the pre- and post-test (1st percentile). His score on the retention test was only slightly higher and converted to the 2nd percentile.

Table 22

The conversion of Peter's VMI (DTVP-2) standard scores to percentiles

Subtests (VMI)	**Pre-test Percentile**	**Post-test Percentile**	**Retention test Percentile**
Eye-hand coordination	5	5	2
Copying	37	37	37
Spatial relations	25	16	16
Visual-motor speed	1	1	2
Total Percentile Ranking	**5**	**3**	**3**

Composite Quotients

According to the DTVP-2 test manual (Hammill *et al.,* 1993) the composite quotient score is the most reliable result to use when interpreting results for a child in order to track changes in his/her integrated VMI performance (all four variables taken into account). The quotient scores for Peter are presented in Figure 75. Peter's pre-test quotient score was 75. It decreased slightly to 73 for the post- and retention test. Despite the apparent changes, Peter's performances stayed in the poor category on each test occasion.

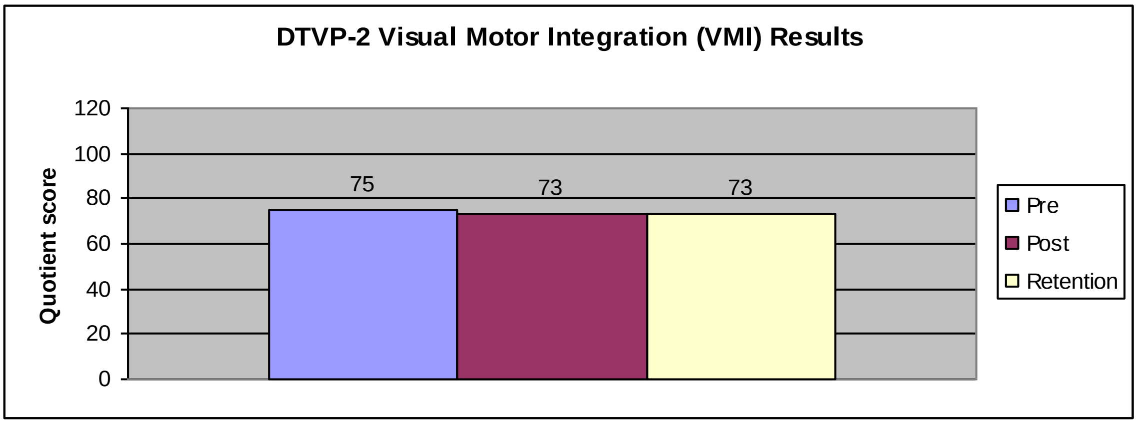

Figure 75. *VMI (DTVP-2) pre-, post- and retention test quotients.*

Research Question Three

15. How did the children feel about their participation in the small group-based intervention programme?

At a separate and individual interview session following the retention test, Peter answered several questions about how he experienced the intervention programme. He indicated he enjoyed the programme and would want to do it again.

Content of the Programme

Peter was asked what specifically he could recall about the activities in the programme, if he felt that he learned anything new, and if it was easier to do the activities toward the end of the programme. Peter remembered throwing different kinds of balls on the rebound nets, balancing activities and jumping or hopping in some of the activities. He felt that he learned to throw and catch with one hand and can do it better now. He also said the activities became easier towards the end of the programme.

Structure of the Lessons

He was asked if he enjoyed the small group sessions or if he would have preferred individual sessions. He was also asked if he could remember the other children in his group. Peter said that he preferred to have friends around him because then it was more fun. He also remembered being in the same group as Luke and David.

Overall Evaluation of the Programme

In terms of his overall evaluation of the programme, Peter said he would like to do the programme again and his favourite activities were throwing the beanbag into the box and throwing and catching with one hand. There was nothing he did not like and overall he enjoyed the programme a lot. He admitted that he did not do his homework.

Post-programme Comments about Peter

Peter seemed to really enjoy participating in the programme but never appeared to be motivated to try to do well or to make progress. His lack of commitment might have been reflected when he said that he did not do his homework.

Besides the motor coordination problems noticed by his teacher, the investigator noticed that he needed her to repeat instructions quite often. He was often unsure about what to do because he either was not listening or was busy doing something else when he should have been listening. He appeared to be easily distracted. If the investigator moved to help another child after an activity had been explained to him, he would start to walk around or play with something else rather than get started on his task.

Peter could get frustrated and angry at himself, a classmate or even the investigator very quickly if he struggled with something. He seemed to be aware of his coordination problems and did not like it when a task was beyond his capabilities.

Case Study Seven: Daniel

Daniel was a seven year old boy in Grade 1 and he was right hand dominant. He was normal height for his age but very thin. He showed signs of hyperactivity and a very short attention span.

On an emotional level he tended to get irritated and frustrated very easily and did not have good listening skills. He sometimes refused to do an activity if it appeared to be too difficult for him or if it was an activity that he did not like. Socially he seemed to get along with the other children in his class, although he had specific friends in his group that he preferred.

He did not have any language problems and his teacher reported no cognitive difficulties. She did think his concentration was weak and that this might cause him more problems in the future. He was identified initially by his physical education teacher because he was seldom interested in physical play and struggled to complete any physical activity once he has started.

Research Question One

16. What were the effects of participation in a small group-based perceptual-motor training programme on selected gross motor skills of children who show signs of DCD?

The results of the five tests of gross motor proficiency (both raw scores and standard scores) on the M-ABC were used to determine the impact of the programme on Daniel. No changes were found in either his eye-hand coordination or his dynamic balance, but these were areas in which his raw scores were quite high or maximum for the test item. The conversion to standard M-ABC scores also indicated that he had no coordination difficulties in these areas, although there was room for improvement of his raw scores on the test of eye-hand coordination (aiming). However, both the raw scores and the standard scores for static balance showed a very good improvement which was sustained on the retention test. It can be concluded that the programme had a positive influence on Daniel’s static balance.

Results for Eye-hand Coordination (Ball Skills)

Two tests assessed eye-hand coordination. Daniel showed deterioration on the first one (aiming) but a good improvement on the second (coincident timing). On the pre-test of the beanbag throw, Daniel got 6 out of 10 throws into the box. On the post-test he scored 9, and on the retention test he scored only 3 out of 10 throws into the box. This can be seen in Figure 76.

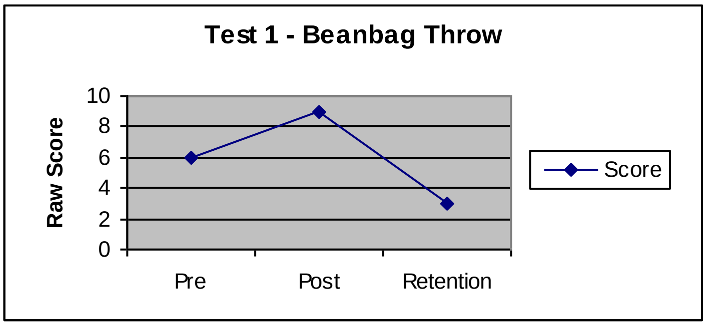

Figure 76. *Raw Scores on the beanbag throw (aiming).*

When Daniel's raw scores were converted to standard scores (between 0 and 5), he achieved a 0 for the first two test opportunities (see Figure 77). These results indicated that for his age, he was not considered to have coordination problems on this test of eye-hand coordination (aiming), although he scored a 3 in the retention test.

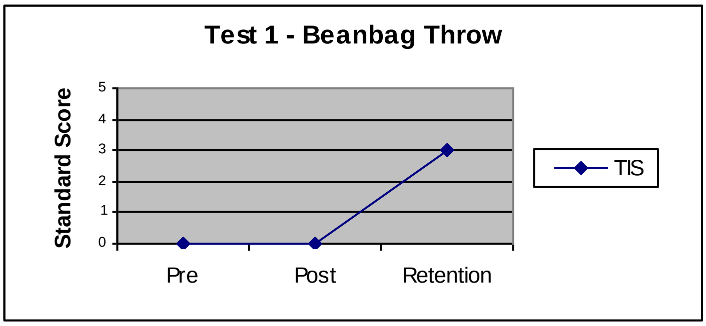

Figure 77. *M-ABC standard score on the beanbag throw (aiming).*

Daniel showed good eye-hand coordination skills in the one-hand bounce and catch test, catching all 10 balls possible with each hand individually on the retention test (see Figure 78). Both the non-preferred and preferred hands showed good improvement with the right hand improving from 3 on the pre-test, to 7 on the post-test and to 10 on the retention test. Performance with the left hand improved from 7 on the pre-test to 9 on the post-test and to 10 on the retention test.

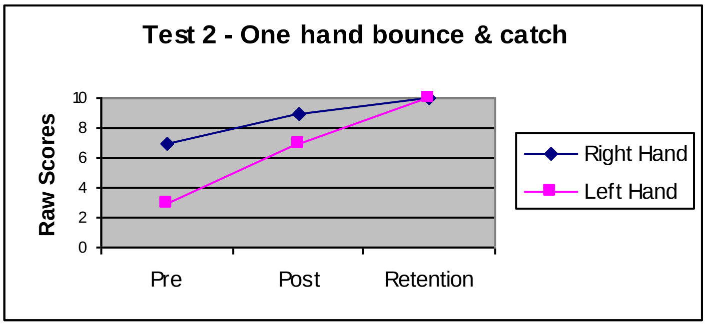

Figure 78. *Raw Scores on the bounce and catch test for right and left hand (coincident timing).*

When converted to standard scores, Daniel pre-test earned him a 3. He achieved full marks of 0 on the other two test occasions, indicating that Daniel had no coordination problems in this area for a child his age (see Figure 79).

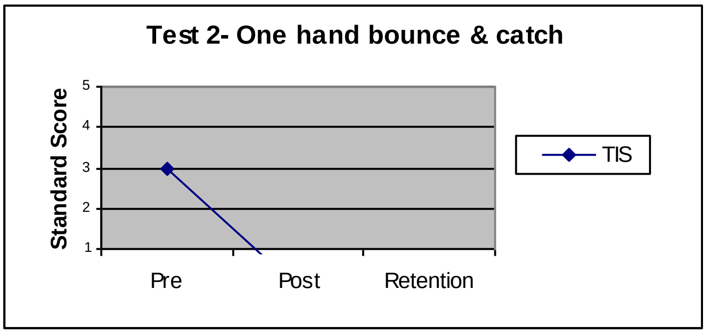

Figure 79. *M-ABC standard scores on the bounce and catch test for right and left hand (coincident timing).*

Dynamic Balance

Daniel did well in both the dynamic balance tests. He completed 5 out of 5 jumps in the squares of the ladder on all three test occasions (see Figure 80).

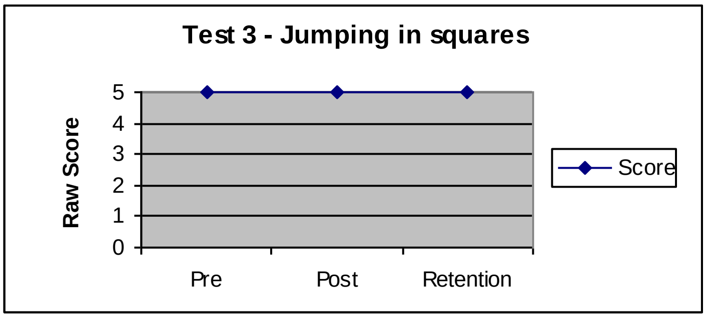

Figure 80. *Raw Scores on the jumping in squares test (dynamic balance).*

Daniel's raw score converted to a standard score of 0 which indicated he had no coordination difficulties with this measure of dynamic balance for a child his age (see Figure 81).

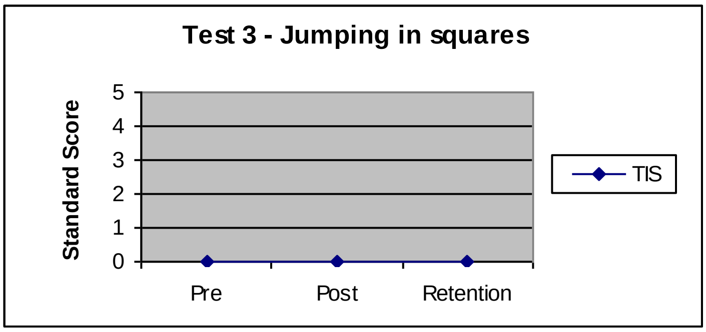

Figure 81. *M-ABC standard scores on the jumping in squares test (dynamic balance).*

On the heel-toe walking test, Daniel once again showed good dynamic balance. He earned raw scores of 15 on all three test occasions with zero number of errors (see Figure 82).

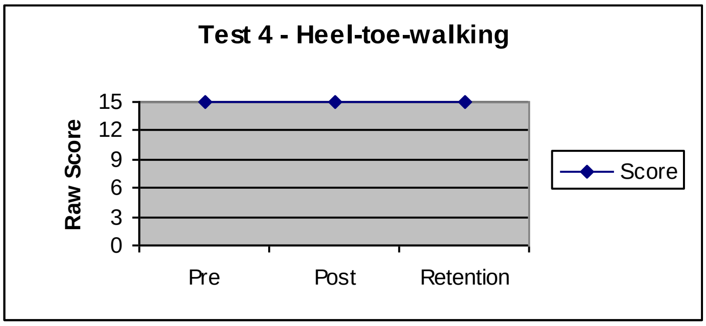

Figure 82. *Raw Scores on the heel-toe walking test (dynamic balance).*

When converted to a standard score, Daniel earned a 0 on all three test occasions, indicating no dynamic balance problems for a person his age.

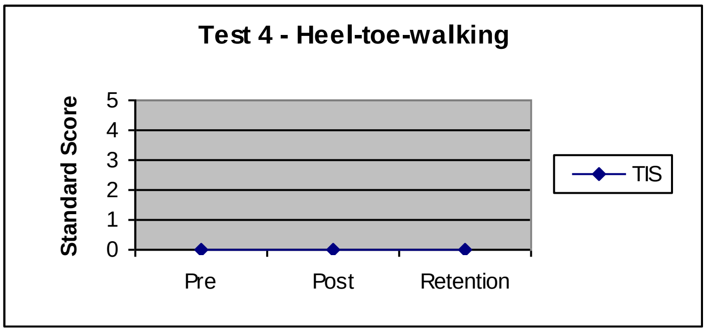

Figure 83. *M-ABC standard scores on the heel-toe walking test (dynamic balance).*

Static Balance

In the test of static balance, Daniel showed a substantial improvement for both his left and right legs from the pre-test to post-test, and he was able to sustain these improvements on the retention-test (see Figure 84). On the pre-test, he could only balance for 10 seconds on the right leg and 18 on the left, but he improved that performance to 20 seconds for both legs on the post-test and again on the retention test.

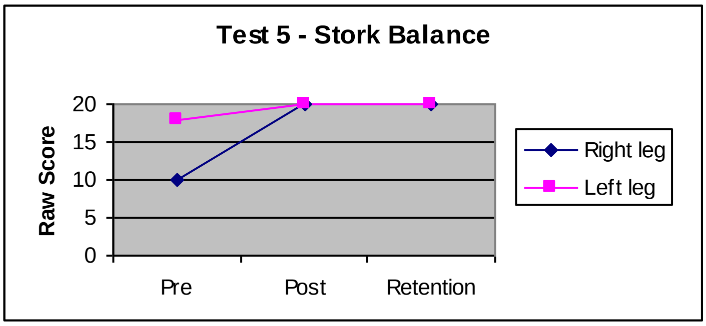

Figure 84. *Raw Scores on the stork balance test (static balance).*

As shown in Figure 85, Daniel's standard scores of 0 on all three tests occasion indicated no problems with his static balance compared to other children his age.

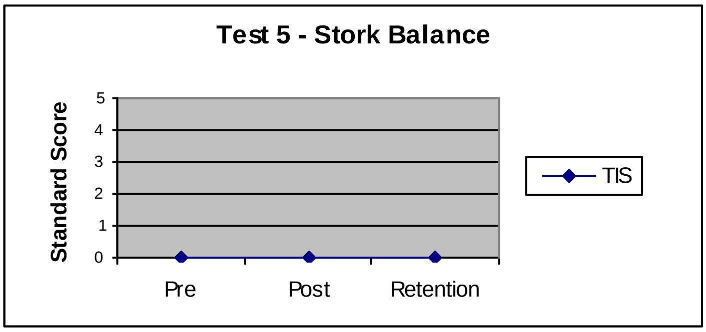

Figure 85. *M-ABC standard scores on the stork balance test (static balance).*

Research Question Two

17. What were the effects of participation in a small group-based perceptual-motor training programme on selected visual-motor integration abilities of children who show signs of DCD?

The results of the four tests of visual perception that assess visual motor integration from the DTVP-2 were used to determine the impact of the programme on Daniel. He showed improvements in both his eye-hand coordination and spatial relations after participation in the intervention programme. There was no real change in his copying scores. After the drop at the post-test, his score went back up to the same as on the pre-test. It was only in visual-motor speed that his test performance deteriorated. When the quotient score that integrates the results of all four tests is considered, Daniel's VMI was rated as poor on the pre- and post-tests and improve to below average on the retention test. This suggests that although there were improvements in eye-hand coordination and spatial relations, the intervention programme did not have much of a slightly positive effect on his overall VMI. The standard scores for Daniel's performance on each of the four variables (pre-test, post-test and retention test) are presented in Figure 86.

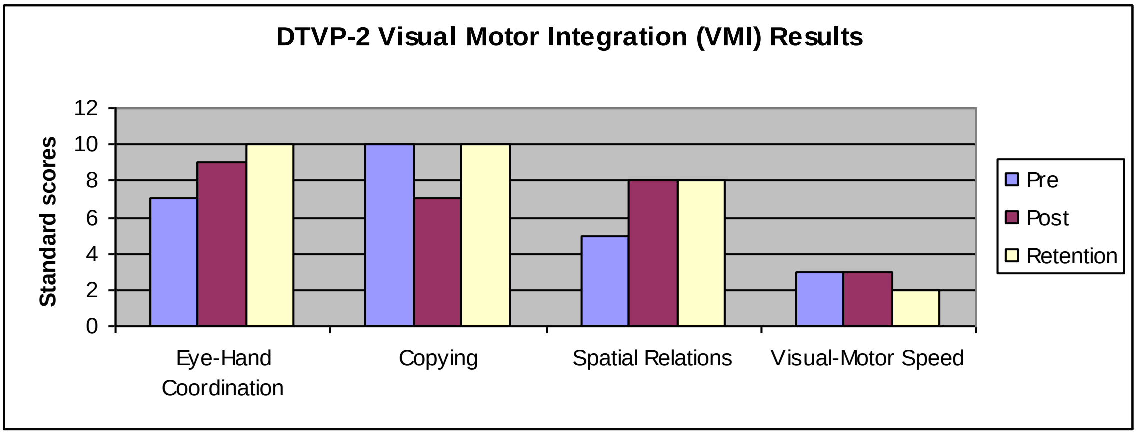

Figure 86. *DTVP-2 (VMI) pre-, post- and retention test standard scores.*

Standard Scores

Standard scores allow the results from the different tests to be compared to each other in order get an integrated picture of Daniel's performance in terms of

VMI. Table 23 presents the sums of the standard scores, and then the conversion of the sums into composite scores. The interpretation of these values into a kind of rating scale is provided in Table 24 and allows a holistic assessment of Daniel's progress in terms of visual-motor integration.

Table 23

DTVP-2 (VMI) Pre-, Post-, Retention test and Composite Scores

Subtests (VMI)	**Standard Scores**		
	Pre	Post	Retention
Eye-Hand Coordination	7	9	10
Copying	10	7	10
Spatial Relations	5	8	8
Visual-Motor Speed	3	3	2
Standard scores total	**25**	**27**	**30**
Percentile	**5**	**7**	**13**
Quotient	**75**	**78**	**83**

Table 24

DTVP-2 (VMI) rating scale for the interpretation of quotients and percentiles

Standard Scores	**Descriptive Rating**	**Quotients**
17 - 20	Very superior	› 130
15 – 16	Superior	121 – 130
13 – 14	Above average	111 - 120
8 – 12	Average	90 – 110
6 – 7	Below average	80 - 89
4 – 5	Poor	70 - 79
1- 3	Very poor	‹70

According to the standard scores that Daniel earned on the individual test items, the following results can be noted:

- Eye-hand coordination improved from the below average category to the average category with his pre-test score of 7 climbing to 10.

- Scores for copying were 10 on the pre-test, 7 on the post-test and 10 on the retention test. His post-test scores dropped his rating to below average but his retention test performance brought it back to the average category.

- The increase in his scores on spatial relations from 5 to 8 increased Daniel's ratings in this category from the poor to the average category.

- His scores for visual-motor speed dropped slightly from 3 on the pre- and post-test to 2 on the retention test. These results kept his rating in the very poor category for visual-motor speed.

Percentile Scores

Percentile scores allow the comparison between Daniel's performance and the performances of other children his age. Table 25 presents his scores on the VMI tests of the DTVP-2 converted to percentiles (his position relative to other children of his age).

- His eye-hand coordination performance improved from the 16th percentile on the pre-test to the 37th percentile on the post-test and the 50th percentile on the retention test.

- Daniel's results for copying placed him in the 50th percentile on both the pre-test, but he dropped to the 16th percentile on the post-test. His score again was in the 50th percentile on the retention test.

- His pre-test performance put him only in the 5th percentile but he was able to record a higher score on the post- and retention-test, both of which converted to the 25th percentile.

- The pattern of his scores for visual-motor speed showed the lowest scores on both the pre-and post-test (1st percentile). His score on the retention-test converted to the 2nd percentile only.

Table 25

The conversion of Daniel's VMI (DTVP-2) standard scores to percentiles

Subtests (VMI)	**Pre-test Percentile**	**Post-test Percentile**	**Retention test Percentile**
Eye-hand coordination	16	37	50
Copying	50	16	50
Spatial relations	5	25	25
Visual-motor speed	1	1	2
Total Percentile Ranking	**5**	**7**	**13**

Composite Quotients

According to the DTVP-2 test manual (Hammill *et al.,* 1993) the composite quotient score is the most reliable result to use when interpreting results for a child in order to track changes in his/her integrated VMI performance (all four variables taken into account). The quotient scores for Daniel are presented in Figure 87. Daniel's pre-test quotient score was 75. It increased to 78 for the post-test and then went up again to 83 on the retention test. Despite the apparent changes, Daniel's performances only went from the poor to the below average category.

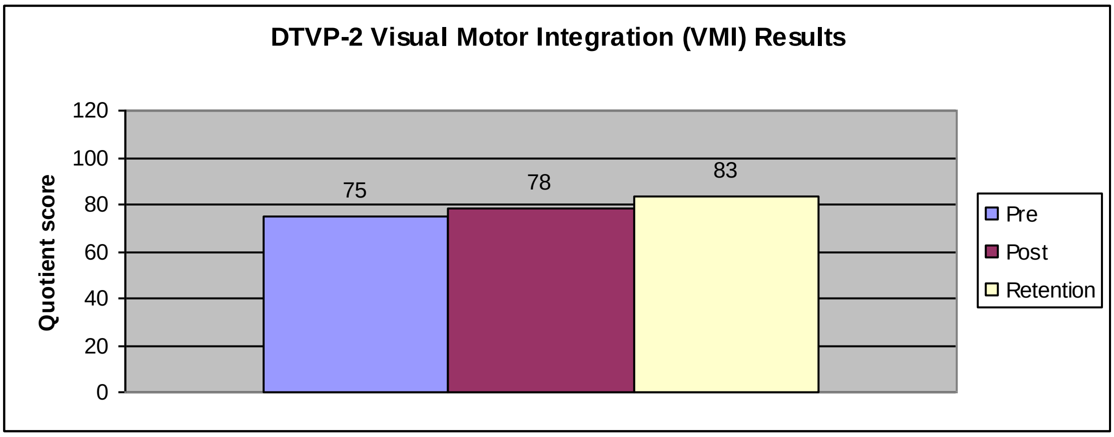

Figure 87. *VMI (DTVP-2) pre-, post- and retention test quotients.*

Research Question Three

18. How did the children feel about their participation in the small group-based intervention programme?

Daniel was absent on the day that the investigator had scheduled for his interview about the programme and could therefore not get any feedback from him.

Post-programme Comments about Daniel

Daniel appeared to have motor coordination problems as well as a concentration problem. He did seem to have the will or motivation to really try to achieve anything. The investigator always had to ask him more than once or ask him very nicely and maybe even promise a surprise if he made an effort and tried an activity. He complained that he was often hurt easily and would never engage in activities that were too physical.

Daniel had very good communication skills and could he speaks fluently, He was not shy to ask or say something. He liked to interact with others in his group and basically the only time when he lacks confidence is when he is asked to do something that he does not think he can do. The investigator could not distinguish between his uses of the phrase “I can’t” to avoid participation because he was just not interested or if he felt he was not capable of performing the skills involved.

Chapter Five

Discussion, Conclusions and Recommendations

The following chapter first presents a discussion about the effects of the intervention programme for each individual case. Conclusions were then made about the effects of the programme in relation to gross motor proficiency and visual-motor integration. Finally, recommendations were made for future programmes and research directions relevant to children who show signs of DCD.

Discussion

The following discussion of each child was based on the standard scores from both the M-ABC and the DTVP-2. The effects of the intervention programme on each child were measured through a pre-test to post-test comparison. Results from the retention tests were discussed within the context of the investigator's experience with each child. To assist the reader:

- Improvements in a child's performance on a test were highlighted in blue.
- Deteriorations in a child's performance on a test were highlighted in violet.
- The colour yellow was used to highlight when there was no change after participation in the intervention programme, but there was either an improvement or deterioration recorded on the retention test.

Mark

The effects of participation in the intervention programme on Mark were summarised in Figure 88.

- Mark achieved an improvement in two areas. His static balance improved as did his eye-hand coordination score on the DTVP-2. There were several training activities that challenged static balance and the investigator encouraged optimal technique, and so practice may have been a factor. His concentration seemed to improve during the programme, which could have contributed to a better score

- His score on spatial relations deteriorated following the intervention programme, and that drop in performance was confirmed on the retention test. Mark did not always appear to give his best, especially if something did not interest him. He may have found the retention test to be a bit repetitive, or may have had difficulties concentrating on this test item.

- Although there was no change in his visual-motor speed following the intervention programme, his score on the retention test indicated an improvement. He may have been involved in activities after the post-test that helped Mark eventually to improve his visual-motor speed.

The programme had a positive impact on Mark's gross motor proficiency. He improved his static balance, the only variable on which he showed signs of DCD, to the point where he now scores in the "no signs of DCD" category on every variable. Mark sometimes showed an attention problem that affected his concentration while busy with a task. This may be why his DTVP-2 results were mixed. Because his overall VMIQ did not change, it can be concluded that there was no significant effect of the programme on his visual-motor integration abilities.

M-ABC	Intervention	Retention	DTVP-2	Intervention	Retention
Eye-hand (A)	No change	Yes	Eye-hand	Improvement	Yes
Eye-hand (CT)	No change	Yes	Copying	No change	Yes
Dynamic Balance (2 ft)	No change	Yes	Spatial Relations	Deterioration	Yes
Dynamic Balance (M)	No change	Yes	Visual-motor Speed	No change	No - score improved
Static Balance	Improvement	Yes	VMIQ	No change	Yes

Figure 88. *A summary of the effects of the intervention programme on Mark.*

Lisa

The effects of participation in the intervention programme on Lisa were summarised in Figure 89.

- Lisa achieved an improvement in three areas. Her static balance improved after programme and improved still more on her retention test. Her DTVP-2 eye-hand coordination score showed an improvement, and that improvement was maintained on the retention test. However, the improvement in her DTVP-2 spatial relations score on the post-test was followed by deterioration on the retention test. She worked hard during the programme, which could account for her improvements in static balance. She started to enjoy throwing and catching activities which could have contributed to her improved eye-hand coordination.

- Her score for eye-hand coordination (coincident timing) did not improve on the post-test, but it did improve on the retention test. Her scores on DTVP-2 visual-motor speed and copying did not change after the programme. Her visual-motor speed score deteriorated on the retention test. Her score for copying improved on the retention test. Lisa's growing enjoyment for throwing and catching activities might have led her to be more active after programme. This would explain retention test improvement.

M-ABC	Intervention	Retention	DTVP-2	Intervention	Retention
Eye-hand (A)	No change	Yes	Eye-hand	Improved	Yes
Eye-hand (CT)	No change	No – score improved	Copying	No change	No – score improved
Dynamic Balance (2 ft)	No change	Yes	Spatial Relations	Improved	No – score deteriorated
Dynamic Balance (M)	No change	Yes	Visual-motor Speed	No change	No – score deteriorated
Static Balance	Improved	No – score improved	VMIQ	No change	Yes

Figure 89. *A summary of the effects of the intervention programme on Lisa.*

Deterioration of visual-motor speed on the retention test might indicate that she needed the stimulation and opportunities of a structured programme in order to maintain progress. The improvement in copying on the retention test could be related to participation in academic activities in the classroom, since the fine motor skills required on the test item involve precise movements for drawing in addition to visual perception ability.

Lisa was a hard worker and somewhat of a perfectionist. She always wanted to be the best and never gave up before she felt she had done it “perfectly.” She put a lot of effort into her participation in the programme, which may be why she improved in her static balance. Her new enjoyment for ball skills could explain her improvement on the retention test on eye-hand coordination (coincident timing). The variety of changes in her performance on the DTVP-2 could be a result of her efforts to be perfect in her performance. All DTVP-2 test items require fine motor and not gross motor skills. She may have felt pressure to be accurate on every test, which could have led to variability in performance. Because there was no change in her overall VMIQ, it can be concluded that the programme did not have a significant effect on her visual motor integration abilities.

James

The effects of participation in the intervention programme on James can be summarised in Figure 90.

- James’s scores on the post-tests showed an improvement in his eye-hand coordination (aiming) as well as his DTVP-2 scores for eye-hand coordination, visual-motor speed and his overall VMIQ. All of these improvements were maintained on the retention tests.

  James’ post-test improvements in static balance and DTVP-2 copying were not maintained on the retention test. There was deterioration in his performance on these two tests from the post-test to the retention test.

M-ABC	Intervention	Retention	DTVP-2	Intervention	Retention
Eye-hand (A)	Improved	Yes	Eye-hand	Improved	Yes
Eye-hand (CT)	No change	Yes	Copying	Improved	No – score deteriorated
Dynamic Balance (2 ft)	No change	Yes	Spatial Relations	No change	Yes
Dynamic Balance (M)	No change	Yes	Visual-motor Speed	Improved	Yes
Static Balance	Improved	No – score deteriorated	VMIQ	Improved	Yes

Figure 90. *A summary of the effects of the intervention programme on James.*

Participation in the intervention programme appears to have been very beneficial for James. He improved his performance on six test items did not show deterioration on any one of them. His eye-hand coordination improved on both the M-ABC and the DTVP-2 and these improvements were retained which shows that the programme had a very positive effect on his eye-hand coordination. The results confirmed James statement that he did his homework. His positive attitude towards the programme and the testing may also have contributed to his success. His improvement in the overall VMIQ quotient suggests that the gross motor perceptual training programme had a positive impact on his visual-motor integration abilities.

Luke

The effects of participation in the intervention programme on Luke were summarised in Figure 91. The results reflect the investigator's observation that Luke had a great deal of difficulty controlling his attention and concentrating.

- Luke's scores on dynamic balance (two feet) and DTVP-2 eye-hand coordination improved on the post-test and those improvements were maintained on the retention test. His scores on dynamic balance (midline), static balance and DTVP-2 visual-motor speed all improved after the programme, but deteriorated between the post-test and the retention test.

M-ABC	Intervention	Retention	DTVP-2	Intervention	Retention
Eye-hand (A)	Deteriorated	No – score deteriorated	Eye-hand	Improved	Yes
Eye-hand (CT)	Deteriorated	No – score improved	Copying	No change	No – score improved
Dynamic Balance (2 ft)	Improved	Yes	Spatial Relations	Deteriorated	Yes
Dynamic Balance (M)	Improved	No – score deteriorated	Visual-motor Speed	Improved	No – score deteriorated
Static Balance	Improved	No – score deteriorated	VMIQ	No change	Yes

Figure 91. *A summary of the effects of the intervention programme on Luke.*

He improved in five subtests just to deteriorate again in three of them. His two feet dynamic balance and DTVP-2 eye-hand coordination improvement scores were retained.

- Luke's score on eye-hand coordination (aiming), eye-hand coordination (coincident timing) and spatial relations all deteriorated after participation the programme. Aiming deteriorated still more on the retention test but coincident timing improved and spatial relations were retained.

- There was no change on Luke's DTVP-2 copying test after programme participation, but his score improved on the retention test. The programme didn't have an immediate effect but he gradually improved over the retention period.

There were changes of some kind in Luke's performance on every test item, sometimes improving, other times deteriorating. His coordination problems appeared to be related to his attention problems. His results were so inconsistent that the investigator cannot determine whether the programme had an effect on Luke. He certainly displayed signs of ADHD and struggled to complete tasks. His motivation to do anything appeared to be low and he seemed to have little confidence in himself. He seemed to achieve according to the mood he was in on a specific day His low muscle tone and clumsy appearance confirmed his M-ABC results that indicated he has some DCD. The lack of change in his overall VMIQ may be attributed to the variation in his scores on the four VMI test items. No conclusions can be made because of the variability of his performances.

Tom

The effects of participation in the intervention programme on Tom were summarised in Figure 92.

- Tom's static balance and his DTVP-2 visual-motor speed improved after participation in the programme. The improvements in static balance were maintained on the retention test; however, the improvements for visual-motor speed appear to have been lost on the retention test.

- He showed deterioration in his eye-hand coordination (aiming) as well as his DTVP-2 spatial relations and overall all VMIQ. Once again, the results from the retention test were mixed. His eye-hand coordination (aiming) deteriorated still more from the post-test. His spatial relations score improved on the retention test and his VMIQ deterioration was maintained.

M-ABC	Intervention	Retention	DTVP-2	Intervention	Retention
Eye-hand (A)	Deteriorated	No – score deteriorated	Eye-hand	No change	Yes
Eye-hand (CT)	No change	Yes	Copying	No change	No – score improved
Dynamic Balance (2 ft)	No change	Yes	Spatial Relations	Deteriorated	No – score improved
Dynamic Balance (M)	No change	Yes	Visual-motor Speed	Improved	No – score deteriorated
Static Balance	Improved	Yes	VMIQ	Deteriorated	Yes

Figure 92. *A summary of the effects of the intervention programme on Tom.*

- There was no change on Tom's copying of the DTVP-2 after participation in the programme, but his score improved on the retention test.

Tom put himself under a lot of pressure. He always strived to be successful and that might have affected the scores. Tom appeared to the investigator to be the steadiest participant in the programme, eager to learn and disciplined with his homework. Perhaps the expectation for improvement created additional pressure. His pre-test scores were reasonably high which did not leave much room for improvement on some test items. He only improved on two tests. The deterioration in his overall VMIQ scores might be associated with the pressure he puts on himself. If he was nervous, the fine motor coordination required for these test items could have suffered and had a negative effect on his scores.

Peter

The effects of participation in the intervention programme on Peter can be summarised in Figure 93.

- Peter's scores on eye-hand coordination (aiming) and eye-hand coordination (coincident timing) improved after participation in the programme. These improvements were maintained on the retention test. He also showed an improvement is his static balance, however, there was a deterioration reported on the retention test.

- His score on DTVP-2 spatial relations showed deterioration after participation in the programme. This deterioration was maintained on the retention test.

- Peter's DTVP-2 visual motor speed did not change from pre-test to post-test, but did show an improvement on the retention test.

Peter appeared to have benefited from the programme. He had good results on the M-ABC, improving in three of the five tests of gross motor proficiency. He got more confident as he became more successful with throwing and catching, which may have led to the improvements in eye-hand coordination.

M-ABC	Intervention	Retention	DTVP-2	Intervention	Retention
Eye-hand (A)	Improved	Yes	Eye-hand	No change	Yes
Eye-hand (CT)	Improved	Yes	Copying	No change	Yes
Dynamic Balance (2 ft)	No change	Yes	Spatial Relations	Deteriorated	Yes
Dynamic Balance (M)	No change	Yes	Visual-motor Speed	No change	No – score improved
Static Balance	Improved	No – score deteriorated	VMIQ	No change	Yes

Figure 93. *A summary of the effects of the intervention programme on Peter.*

Peter was not able to sustain his static balance improvement, but if the programme had been longer, he might have been able to practice enough to have maintained the initial improvement. The programme did not appear to have a lasting effect on his visual motor integration abilities because there was no change in his general VMIQ. His deterioration on the spatial relations item might be a specific problem he had with that particular test. His improvement on the retention test in his visual motor speed suggests that he may have been a bit tired on the post-test, which could explain why there was no change from the pre-test. This was the fourth item on the test, and Peter was usually very much focused and had a positive attitude.

Daniel

The effects of participation in the intervention programme on Daniel were summarised in Figure 94.

- Daniel improved his eye-hand coordination (coincident timing) as well as his DTVP-2 eye-hand coordination and spatial relations. These improvements were all maintained on the retention tests.

M-ABC	Intervention	Retention	DTVP-2	Intervention	Retention
Eye-hand (A)	No change	No – score deteriorated	Eye-hand	Improved	Yes
Eye-hand (CT)	Improved	Yes	Copying	Deteriorated	No – score improved
Dynamic Balance (2 ft)	No change	Yes	Spatial Relations	Improved	Yes
Dynamic Balance (M)	No change	Yes	Visual-motor Speed	No change	Yes
Static Balance	No change	Yes	VMIQ	No change	No – score improved

Figure 94. *A summary of the effects of the intervention programme on Daniel.*

- Daniel's score on his DTVP-2 copying deteriorated after participation in the programme. However, his score improved from the post-test to the retention test.

Daniel improved his catching technique and tracking of the ball, which is reflected in his improvement in eye-hand coordination on the M-ABC. His improved eye-hand coordination and spatial relations items on the DTVP-2 goes well with this result. The deterioration on the M-ABC aiming task on the retention test could be because Daniel did not have any practice for this particular type of activity in the period between assessments. Although Daniel did not record a change in his overall VMIQ after participation in the programme, there was an improvement on the retention test. The investigator was surprised at Daniel's improvements on the tests because he seemed to need a lot of external motivation to keep him going during the programme. Perhaps the small group work in which he got some individualised attention but still had to work independently sometimes, was of benefit to his ability to work without constant supervision.

Conclusions

Looking at the M-ABC results, the programme had the biggest effect on static balance of the children who showed signs of DCD. Six of the seven subjects improved in their scores from pre- to post-testing. The reason why they showed little or no improvement in dynamic balance and hand-eye coordination might be because they scored high scores on the pre-test, so it was not possible to detect whether or not there were any changes. Their weakest area was static balance and the programme succeeded to improve their skills in that area.

The DTVP-2 results showed improvements in eye-hand coordination in five children after the intervention programme. The other visual abilities showed little or no improvement. This could be because the intervention programme emphasised eye-hand coordination specifically. According to the VMIQ score (the most valid indicator of visual-motor integration) only one child improved, one deteriorated and the other children showed no change. This brought the investigator to the conclusion that the perceptual-motor training programme was not effective for the development of visual-motor integration as measured by the DTVP-2.

M-ABC Results and DCD

Wilmut *et al*. (2007) estimated 5% – 10% of children present deficits in the coordination of eye and body movements. According to past research, children with DCD only learn how to catch a ball at a much later point in time than their peers. Astill and Utley (2006) found that children with coordination problems initiate reaching movements later and are more variable in the time it takes them to initiate movements than children without coordination problems. In the examination of how children catch a ball, Van Waelvelde *et al.* (2004) found that children with DCD have difficulties catching a ball because of grasping errors and hand placement errors.

These characteristics were found among the children who participated in this study. The perceptual motor training programme in this study was dominated by the gross motor skills of throw, catching and challenges to balancing. Every training session included activities using the rebound nets which emphasised eye-hand coordination. The children's static balance improved, and it was the investigator's observation that their throwing and catching improved also. This positive outcome for the programme correlated well with the literature. Johnson and Wade (2007) also found that interventions targeting specific functional skills were beneficial for children with movement difficulties like DCD. Pless and Carlsson (2000) also recommended the skill-specific/ task-specific approach.

Children with DCD have been found to have deficits in proprioception (Pryzysucha *et al.* 2007; Hamilton, 2002). Deconinck *et al.*, (2006) found that kinaesthetic perception, specifically proprioception, was deficient in many children with DCD. For this reason, many of the activities in the intervention programme in this study included challenges to balance control, often using the physio-ball for sitting or balancing, and one-foot balance activities, such as throwing and catching. Astill and Utley (2006) suggested that children with DCD rely more on visual information than proprioceptive information (like typically developing children) for feedback to control their movement performance. By keeping the children's vision occupied with throwing and catching activities, the investigator hoped to promote the development of the children's reliance on proprioception for balance control.

Developmental milestones are certain motor skills that are acquired during predictable time periods in a child's life (Learning Disabilities Association of America, 1999). When a child has motor difficulties that include slowness of movement and information processing, there are often deficits in muscle power and strength, leading to low muscle tone. When child seems to lag in achieving these milestones or presents some signs of movement coordination problems, there is concern that he/she may have DCD. A child may be identified for assessment for DCD if muscles seem floppy and loose, one side of the body is particularly favoured over the other, motor skills seem to be regressing compared to peers, etc. These are the kinds of signs that led the physical education teachers who assisted in this study, to identify candidates for the programme.

The M-ABC is valuable as a diagnostic tool for DCD. It is less sensitive for assessing movement difficulties of children who are more mildly affected. The tests all have an upper limit on attempts, which makes it impossible to discriminate among children who have achieved the maximum scores. It can be concluded that the children in this study had coordination problems, but that their problems were not so severe as to categorise them as having DCD. This does not take away, however, from the importance of helping them improve their gross motor skills. Their teachers had identified them as having movement coordination problems that had a negative effect on their participation in physical activities. The investigator believes that the perceptual motor training programme implemented in this study had a generally positive impact on the children's throwing and catching skills and made a particular contribution to improvements in their static balance.

DTVP-2 Results and DCD

The results of the DTVP-2 indicated that the children were relatively weak in terms of their visual-motor integration abilities. There are seven categories ranging from very poor to very superior on the DTVP-2, and the average category lies only at the 50th percentile. The highest VMIQ score for any child in this study was only in the average category. The remaining six children all scored at less than the 50th percentile on all three test-occasions. It is possible that the children's apparent low visual-motor integration abilities contributed to the motor coordination problems observed by the teachers in physical education.

According to the literature on clumsy children they also have problems with proprioception, sensory integration and visual processing (Hamilton, 2002). Numerous studies suggest that children with DCD have deficits in their visual-perceptual skills (Tsai *et al*., 2008). Deconinck *et al*. (2006) also speculated that the trouble children with DCD have predicting the flight path of a ball could be an indicator of problems with their visual skills or visual memory.

When looking at individual test items on the DTVP-2, the lowest scores were reported for visual-motor speed. This is compatible with the findings of Hoare and Larkin (1991) who found that children with coordination problems had trouble controlling their speed, force and direction when performing movements with task demands on visual perception. Mon-Williams *et al.* (1994) concluded that the motor control problems of children with DCD associated with their visual system was related to the integration and interpretation of visual information (*e.g*. visual-motor integration).

While the potential relationship between visual-motor integration and DCD has been explored in the research, this study did not find that the intervention programme had any impact on the children's visual-motor integration abilities as measured by the DTVP-2. It is important to note that the intervention programme was entirely focused on gross motor skills and the DTV-2 only requires fine motor skills. Although the control systems for these two types of skills might be the same, the effects of practice and the acquisition of motor programmes are quite specific to practice situations. If the programme had been focused on fine motor skills, there might have been an impact on DTVP-2 scores.

Benefits of the Programme

In addition to some benefits for gross motor skills, the investigator observed some secondary emotional and behavioural benefits from participation in the programme. All of the children became more confident as the programme went on and they also started to take more risks by trying out new things. They improved in their ability to cooperate in a small group setup. Not only did their listening and attention skills improve, but also their self control. Children who sometimes struggled with frustration management seemed to become more able to stay on-task longer than at the beginning of the programme.

The fact that there were four children together with the researcher at a specific time forced them to interact and get socially along with the others. They had to cooperate and wait for their turn, as well as share equipment. They also had to listen to instructions and pay attention/concentrate when having to work against a time limit. Because children with DCD are likely to have secondary behavioural and emotional problems, this programme was considered successful by the investigator because of these secondary outcomes that can make a significant contribution to the total development of a child.

Recommendations

The following recommendations are made by the investigator, based on the results of this study:

Professional Practice

- Barnhart *et al*. (2003) found that different classification systems for DCD are influenced by the type of motor test being used. The standard scores provided by the M-ABC may be appropriate for the diagnosis of DCD, but should be supplemented by additional tests of motor proficiency when working with children who may only be mildly affected.

- When looking at intervention programmes to treat DCD, it is important that any researcher should keep in mind that no single approach works for all children and that when deciding on a type of programme, one child might respond and another one not. It was extremely interesting to the investigator to see that the children in the programme improved at different rates in different aspects of their behaviour (motor and social). While a perceptual motor training programme might need to be individualised for each child, gaining social benefits might rely on group-paced experiences.

- The investigator's overall experience of the programme was that it could be effective for addressing gross motor coordination problems, but should be implemented on a more long-term basis. It is suggested that this one can be combined with more vision specific exercises because if children's visual perception can improve, their gross motor skill level will also increase.

Research

- Luke has at the age of seven not developed a dominant hand, still gets confused with what is left and what is right and sometimes show signs of midline crossing problems when he has to catch a ball thrown at his side with two hands. When looking at Luke, James and Peter it is clear that they all have a poor pencil-grip which resulted in poor results of the DTVP-2. The full DTVP-2 test battery also includes four motor-reduced test items that only test visual motor abilities without fine motor coordination. Future research with children who show signs of DCD should include administration of the full battery so that low scores can be accurately attributed to either fine motor coordination problems or weak visual perception abilities or both.

- Luke and James both said that in future they would like to do their exercises on their own instead of in a small group, because they felt too much pressure in a group situation. Peter has a very low self-esteem and Lisa showed feelings of incompetence and disbelief in her own abilities. Tom was the introvert of the seven and James and Daniel got very frustrated when they struggled with an activity. Future research should include measurements of psychological dimensions as well as motor aspects in order to determine the impact of an intervention programme on secondary characteristics of DCD.

Final Comments

The investigator had the impression that the intervention programme had a positive impact on the gross motor proficiency of all the children, in particular for skills that require static balance. The impact of the programme on visual-motor integration abilities could only be inferred from increased success and enjoyment in throwing and catching activities experienced by most of the children.

The difference between gross motor skills and fine motor skills were quite evident to the investigator. The DTVP-2 required fine motor skills and visual-motor integration. The intervention programme was focused on gross motor skills that also required visual motor integration. The programme focused specifically on large body movements whereas the DTVP-2 requires a good pencil grip for fine motor performance. The results of this study suggest that the development of gross motor skills is not necessarily associated with the development of fine motor skills, and that children who show signs of DCD, need intervention programmes that target both areas for specific development.

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Appendix A

One-hand Bounce and Catch

Preferred hand	Non-preferred Hand

Age 7	Age 8	Score		Age 7	Age 8
9-10	10	0	0	8-10	9-10
8	9	1	1	7	8
7	8	2	2	6	7
6	7	3	3	5	6
4-5	5-6	4	4	4	5
0-3	0-4	5	5	0-3	0-4

Item Score

Throwing Bean Bag into box

Score	Age 7	Age 8
0	6-10	6-10
1	5	5
2	4	4
3	3	3
4	2	2
5	0-1	0-1

Hand used	Item score

Appendix B

Letter to Headmaster

29 October 2008

Dear Sir

I am currently busy with my Masters degree at the University of Stellenbosch and my topic is children with motor control challenges. My study will explore the success of a visual skills training programme in helping them to improve their gross motor skills. I have designed an intervention programme based on eye-hand and foot-eye coordination activities, to be implemented 1x per week for 8 weeks (45 minute practices sessions). I am asking for your permission to offer this programme to seven children between the ages of 7-10 in your school who have been identified as lagging behind their peers in terms of their motor skills. The consent of the parents of the children identified would be necessary, as well as the consent of the children.

If acceptable to you, I would like to follow this procedure:

I will identify children who appear to be lagging behind their peers after observing their Physical Education classes and consulting with their teachers. I will generate a list of children who are candidates for the programme, then send the list to you for screening. You will be asked to help me identify which children could benefit from the programme. I would then provide you with a letter to send to the parents, explaining the purpose of my study and how the intervention programme would be provided during the school day so that the children did not miss out on their other academic activities.

The children whose parents would like them to be involved in the study will then be approached and asked if they would like to participate. If the children agree, I would then ask them to take the Movement ABC test, a simple field test of balancing, throwing and catching, jumping, etc. This would serve as the pre-test, and would be administered again at the end of the study to determine if the children had made any progress.

I anticipate that this study would begin as soon as possible in the first term of 2009. Justine and Elana have been so kind to allow me to observe some of their classes until the end of the year so that I can get a sense of the children in your school and how they behave during physical education experiences. This will also allow us to try to identify possible children for the programme.

I appreciate your willingness to consider my request and would be eager to make an appointment with you to discuss my study in further detail.

Thank you

Christine Markgraaff
(BA Sport Science; Honours Paediatric Sport Science)

Appendix C

Information Sheet

Thank you for your time and interest in my study. The topic of the study is: ***A Programme to Improve Selected Perceptual and Motor Skills of Children Who Show Signs of Developmental Coordination Disorder (DCD)***

Background

It is described by experts that 6% - 10% of all school-aged children lag behind their peers in terms of both their fine and gross motor skills. According to the American Psychiatric Association (APA, 1994) a "child who experiences movement difficulties that are out of proportion with their general development in the absence of any known medical condition or identifiable neurological disease, is classified as having Developmental Coordination Disorder (DCD)".

DCD is characterized by motor development delays and/or motor skill deficits that have a negative impact on the gross motor proficiency levels and other daily activities of children. It is defined as a motor-based performance problem because the motor coordination deficits/delays experienced limit the child's ability to fully participate in some of the everyday activities of childhood. Visual perception has been found to be one of the sources of these movement coordination deficits and special activities to develop visual skills has also been recommended.

Purpose

The purpose of my research is to determine the effects of participation in an individualized motor development programme on the motor proficiency and the visual perception of children who show signs of DCD (children who are lagging behind their peers in terms of their motor skill coordination).

Design

A case study approach will be followed, which means that:

- Only seven children between the ages of 7 and 10 years, who show signs of DCD, will actually be the “subjects” in the study.
- Each child in the study will be tested several times to document his/her progress, rather than tested in order to be compared to any other children.
- An individual report will be written describing each child’s progress. This report will be made available to the school and to the parents.

Identification of participants

Children will be referred by their physical education teacher for participation in this study, based on observation during sport and physical education lessons. Permission from parents will be necessary before asking the children if they would like to participate in the special programme.

Assessment

Pre-, post- and retention test assessments will include:

- Movement ABC test: A fundamental movement performance test.
- The Developmental Test for Visual Perception-2: A paper-and-pencil test.

Intervention programme

What: The programme will be centred on eye-hand and foot-eye coordination activities using the Crazy Catcher rebound-nets. The children may be asked to do some coordination activities as “homework”, but these activities will not require special equipment or a substantial investment of time.

When: The programme will be offered during each child’s regularly scheduled physical education period in order to prevent any disruption in his/her academic schedule.

For how long: The programme is planned to run for eight consecutive weeks (including the testing).

How to avoid negative “labelling” of the participants: In order to minimise the risk that the children who participate in the study feel isolated from their physical education class, the following two features of the programme have been included:

- The individualised programme will be delivered in small groups of 3-4 children, but all of the children in a small group need not be actual participants in the study. Some of them simply may be volunteers from the same physical education class who want to try the programme. No data will be kept on these children, but the fact that they participate in the small group should take away any stigma that the small group is only for children who have coordination challenges.

- Three Crazy Catcher nets will be provided to the physical education teachers during the duration of this study so that the nets can be used during regular physical education class by the other students who are not participating in this study. From the children’s point of view, then, some children work on the nets in a small group, but the other children also get to work with the nets in their larger class group.

Benefits

The intervention programme will be delivered in a manner that will emphasise enjoyment and treat each participant with respect. Individualised practice sessions should help participants improve their motor skills and thus provide them with a stronger basis from which to join in the sport and physical activities of their peer group. It is also possible that as a consequence of improved movement skills, they will experience positive self-esteem. The small group work included in this project also may support the development of their socialization skills.

Appendix D

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

20 February 2009

Dear Parent,

I am currently busy working on my Masters degree in Sport Science at Stellenbosch University. My focus area is primary school children and my research will explore the success of a physical activity programme in helping them to improve their fundamental motor skills and their visual skills.

I have designed an intervention programme based on eye-hand and foot-eye coordination activities, to be implemented 1x per week for 6 weeks (each session is 45 minutes long). Because I am particularly interested in helping children who may be lagging behind their classmates in terms of their motor skills, I have designed the programme to be presented to small groups of 3 or 4 children at a time. I have also decided to follow a case study approach and therefore will only be charting the progress of each child compared to his or her own starting level, rather than compare children to each other.

Your child has been recommended to me by his/her teacher as a child who might enjoy this kind of individual practice and who might benefit from the specialised coaching I would provide. My programme would be offered during the regular physical education period, so no disruption of your child's school day would occur. I will be working with small groups of children each period so that no one child will feel he/she has been singled-out as needing special help. Therefore I am asking for your permission to discuss this programme with your child. I hope your child will be interested and want to volunteer, but will respect your child's decision should he/she decline. Also, your child would be free to stop participation in the programme at any time over the 6 week period, although I believe that the programme will be both interesting and fun and that all the children will want to stay involved.

I will be working in close cooperation with the school and all sessions will be offered there. Your child may be asked to do some physical exercises as “homework”, but home activities will not require special equipment and will not take time away from other activities. I will be able to report your child’s progress to you at the end of the study. Pre- and post-test assessment includes:

- The Movement ABC test: This is a movement performance test that measures static and dynamic balance, hand and foot-eye coordination, body awareness and locomotion.
- The Developmental Test for Visual Perception-2 (DTVP-2): This test is a paper-and-pencil test that measures perception of size constancy, perception of figure-and-ground, perception of whole-and-parts and perception of spatial orientation.

Please return this form with your signature if you consent to allow your child to participate in this study. I will be available to you throughout this project should you want to discuss any aspect of your child’s participation. I anticipate that the study will be completed before the Easter break.

Please do not hesitate to contact me should you have any questions at any time.

Kind regards

Christine Markgraaff	Prof ES Bressan, Research Supervisor
Cell: 082 7885 580	Cell: 082 785 3385

I understand the nature of this project and that participation is voluntary.

I give my permission for Christine Markgraaff to discuss this project with my child and to offer him/her the opportunity to participation. If my child is interested in the project, I consent to that participation.

Name of your child: ______________________________________

Your name printed: ______________________________________

Your signature: ____________________ Date: ______________

A contact telephone number for you: __________________________

Appendix F

Net Activities

- 2 – 4 catching with the outside people slightly closer to the Crazy Catch.

- Have a No 1 position and rotate when a catch is dropped or lose a point for each dropped catch
- How many out of 5 or 10 or more attempts can you catch. Can the next person beat your score.
- Successfully catch 5 and then the next person has a go.
- Keep going until you drop a catch and then give the next person a turn. See who can get the highest score.
- Start off at 2m and catch 5. Move back a metre and catch another 5. Keep moving out to eg 10 metres and time your group to see how long it takes.
- Have two people in close with as many as you like further out. The two close-in people are the throwers and they throw hard. They attempt to catch while the rest pick up the misses. Rotate positions.

Appendix E

LESSONPLAN **Week 1**

Participants: ____________________ **Age:** ___________ **Equipment used:** ____
____________________ **Age:** ___________ ____
____________________ **Age:** ___________ ____
____________________ **Age:** ___________ ____

- **Activity 1:** ____
- **Activity 2:** ____
- **Activity 3:** ____
- **Activity 4:** ____
- **GAME:** ____

Visual Skills	Gross Motor Skills	Relationship to Environment	Relationship to Equipment	Time/Speed
1. Eye-hand Coordination	• Throwing & catching	• Both person & environment static	• Vary size of balls	• 1 RM
2. Depth perception	• Hopping & jumping	• Person static & environment dynamic	• Vary colours of balls	• Sets: 1 = 5 repetitions, 2 = 10 repetitions etc.
3. Figure-ground	• Crawling & climbing	• Person dynamic & environment static	• Instructions: Under, over, through, around	• 30 sec/1 minute continues
4. Peripheral vision	• Kicking & striking	• Both person & environment dynamic	• Vary equipment: ladders, cones, ropes	• Fast/Slow
5. Whole-parts	• Walking & stepping		• Vary size and angle of net	• Accelerate/Decelerate
6. Size constancy	• Rolling & running			
7. Movement	• Turning & twisting			
8. Visual-response time	• Balancing			
9.	• Skipping			

Appendix G

Questionnaire

Name: _________________ **Date: ____________**

1. Do you remember the lessons we did in the first term?

   ____

2. Is there something specific about it that you can recall?

   ____

3. Do you feel that you learned anything new in the programme?

   ____

4. Did the exercises become easier towards the end?

   ____

5. Do you feel that your gross motor skills (throwing & catching and balancing) improved?

   ____

6. What did you enjoy most about the lessons? And why?

   ____

   ____

7. What did you like least about the lessons? And why?

   ____

   ____

8. Have you told your parents about the exercises on the nets?

   ____

9. Will you do the programme again? Why/why not?

____

10. Did you enjoy playing on the nets?

____

11. How did you find the group sessions? Did you like working in a small group?

____

____

Or would you rather have preferred one-on-one sessions? Why?

____

____

12. Did you do your homework? And who helped you with it?

____

If not, why not?

____